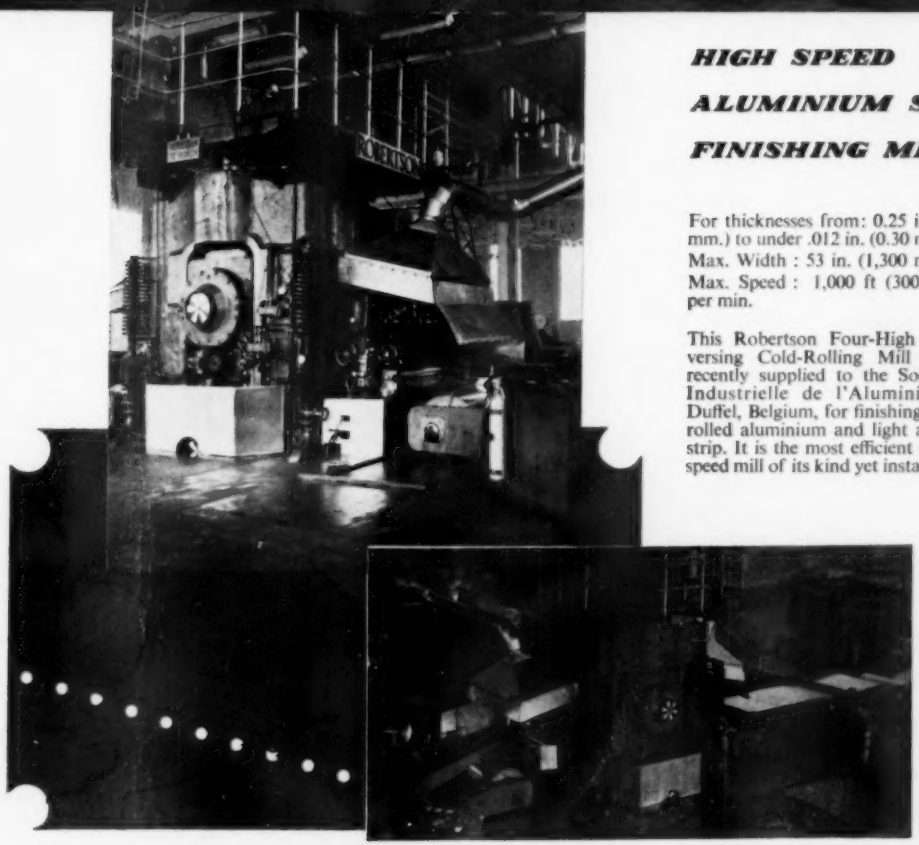
Sheet Metal Industries

SEPTEMBER 1960



HIGH SPEED ALUMINIUM STRIP FINISHING MILL

For thicknesses from: 0.25 in. (6 mm.) to under .012 in. (0.30 mm.)
Max. Width : 53 in. (1,300 mm.)
Max. Speed : 1,000 ft (300 m.) per min.

This Robertson Four-High Reversing Cold-Rolling Mill was recently supplied to the Société Industrielle de l'Aluminium, Duffel, Belgium, for finishing hot rolled aluminium and light alloy strip. It is the most efficient high speed mill of its kind yet installed.

THE ROLL STAND. Roll housings and bearings are of massive construction. Support rolls float in Robertson film lubrication bearings which remain cool at sustained maximum loads and speeds. Back tension on the strip during the initial run is applied by a multi-roll bridle. This unit is hydraulically controlled and of a new and improved design.
Roll temperature is controlled by valves which regulate the quantity and distribution of the rolling oil. Wiper rolls prevent rolling oil from passing on to the coiled strip. Strip thickness is continuously checked by flying micrometers. 1,000 h.p. main mill motor drives the rolls through totally enclosed, double helical, jet-lubricated pinion drive. It delivers constant torque up to half speed, and thereafter constant horse power up to full speed.

W.H.A. ROBERTSON & CO. LTD

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LICENSEES FOR THE BUILDING OF SENDZIMIR COLD REDUCTION MILLS AND PLANETARY HOT MILLS. HALLDEN GUILLOTINE AND ROTARY FLYING SHEAR MACHINES, AND TORRINGTON METAL WORKING MACHINERY

WT.275R

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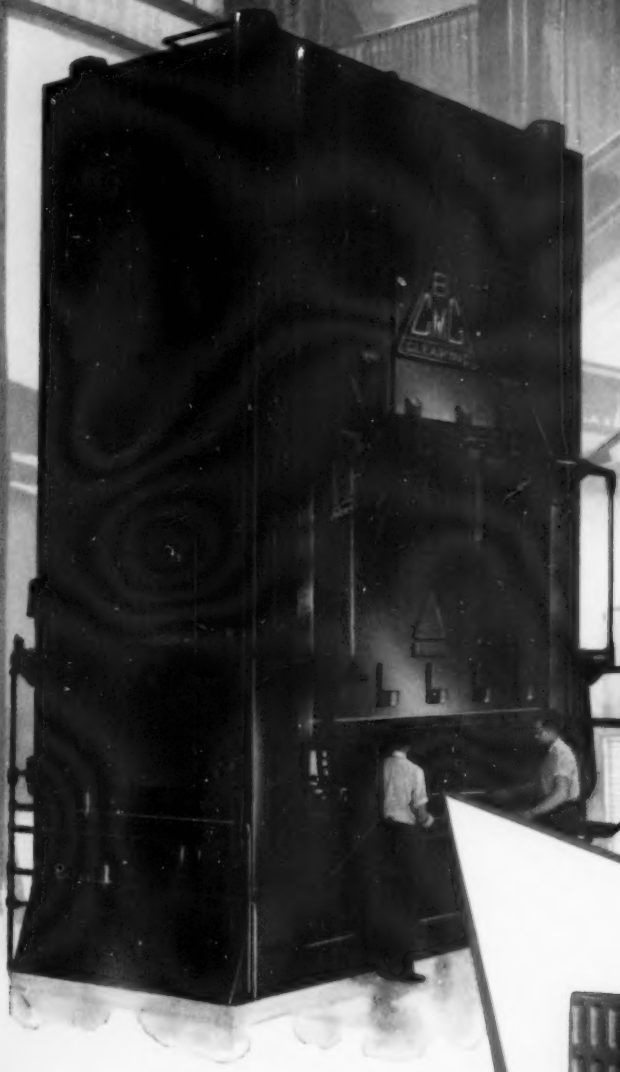
BRITISH CLEARING Presses

Built by

VICKERS

help to produce High Quality Domestic Appliances



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Made on 600 ton BRITISH CLEARING Press

This British Clearing Press installed in the second of two new factories built for Messrs. DIMPLEX LTD., at Southampton is helping their major development plan in fulfilling the large demand for 'Dimplex' products.

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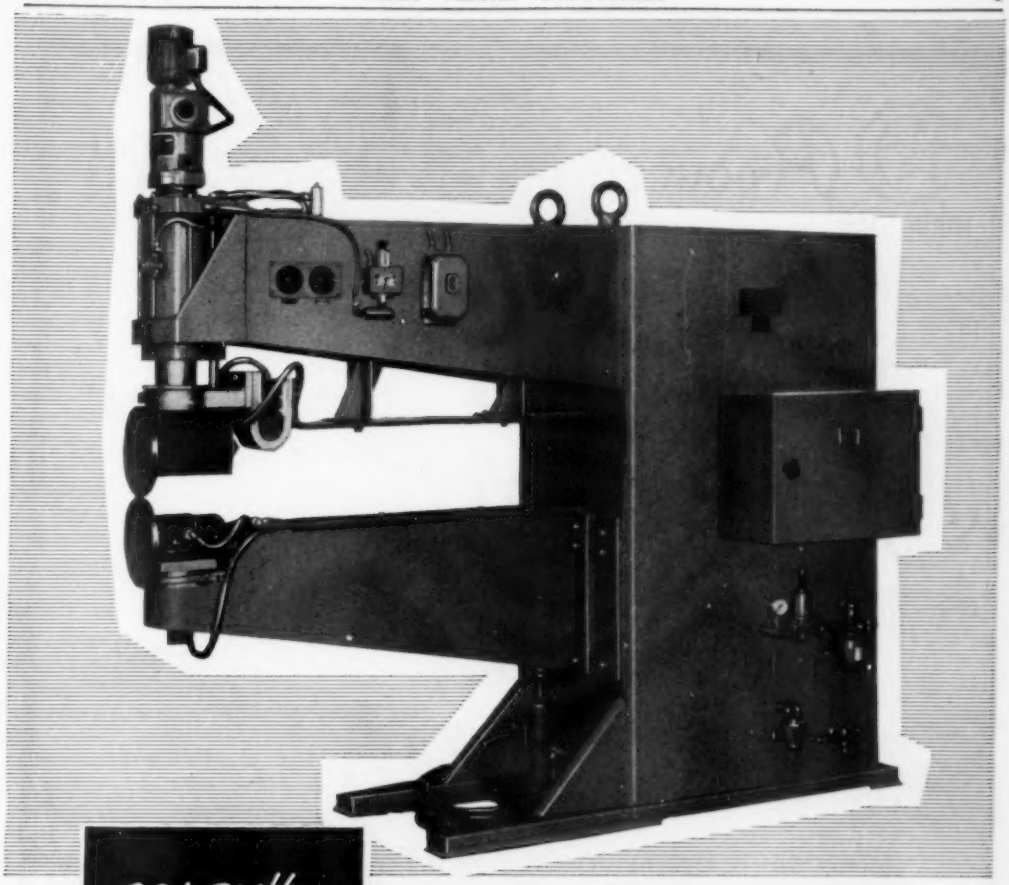
WT.275R



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ASEAWELD
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Editorial Contents. page 637

Classified Advertisement pages. 117

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stretch dies

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CVA EPIFORM formulated resins give high dimensional accuracy, high compressive strength; high impact strength; good resistance to abrasion and corrosion; absence of cold flow and good adhesion to metal inserts and lifting bolts.

CVA EPIFORM tooling has the advantage of reduced cost and time of manufacture; reduced weight; ease of manufacture; modification and repair, and requires lower toolroom equipment investment.

In addition to the complete manufacture of patterns and tooling, CVA offer a full technical advice service on the use of EPIFORM materials which can be supplied separately for customers' use.

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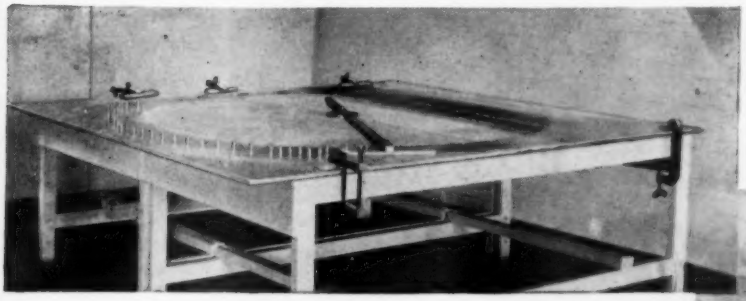
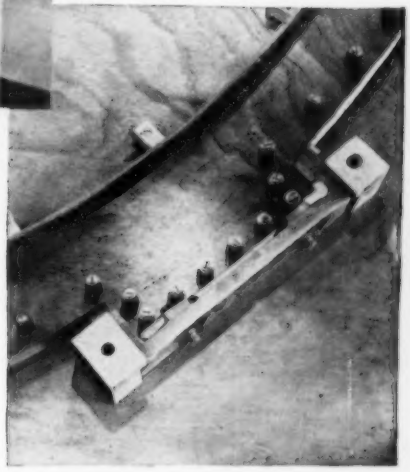
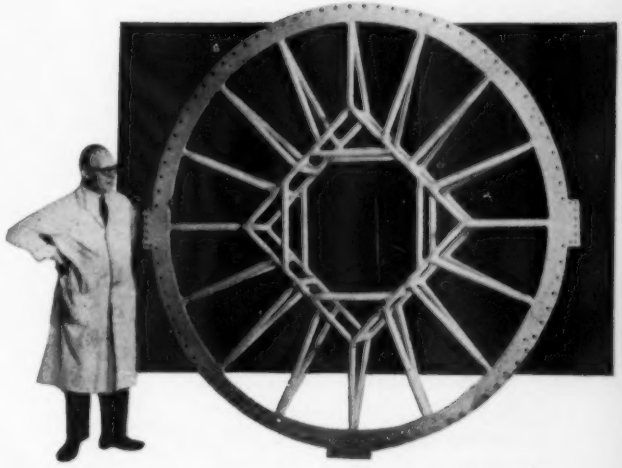




5ft. DIAMETER DRILL JIG PRODUCED AT ONE-THIRD COST AND ONE-SIXTH WEIGHT OF CONVENTIONAL STEEL JIG

The illustrations show some of the stages of fabrication. A drill bush location plate is spigoted to the prepared working surface-bushes and metal inserts are positioned and fixed with wood screws and the 'dam' is built up—after fabricating the main ring the final step is to cement in the structural members.



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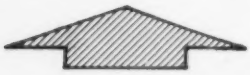
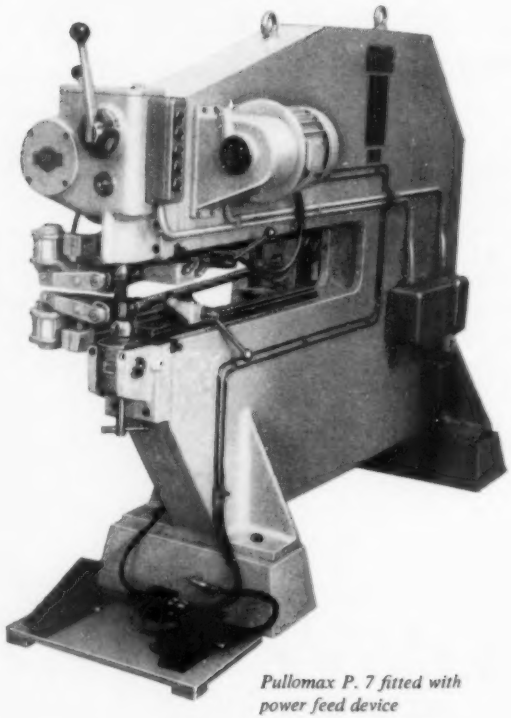


A typical joggling operation carried out on a Pullomax in 7 MINUTES.

Over-all Dia.	*13¾"*
Joggle	*⅛" Deep*
Material	*16 s.w.g. mild steel*

The Pullomax Machine has effected considerable savings in the production of a variety of components. The above illustration is a typical example. Operations can be carried out on mild or stainless steel, brass, copper, aluminium, magnesium, wire mesh, fibre board and certain plastics. Made in 5 sizes up to a maximum edge-cutting capacity of ¼" in mild steel plate.



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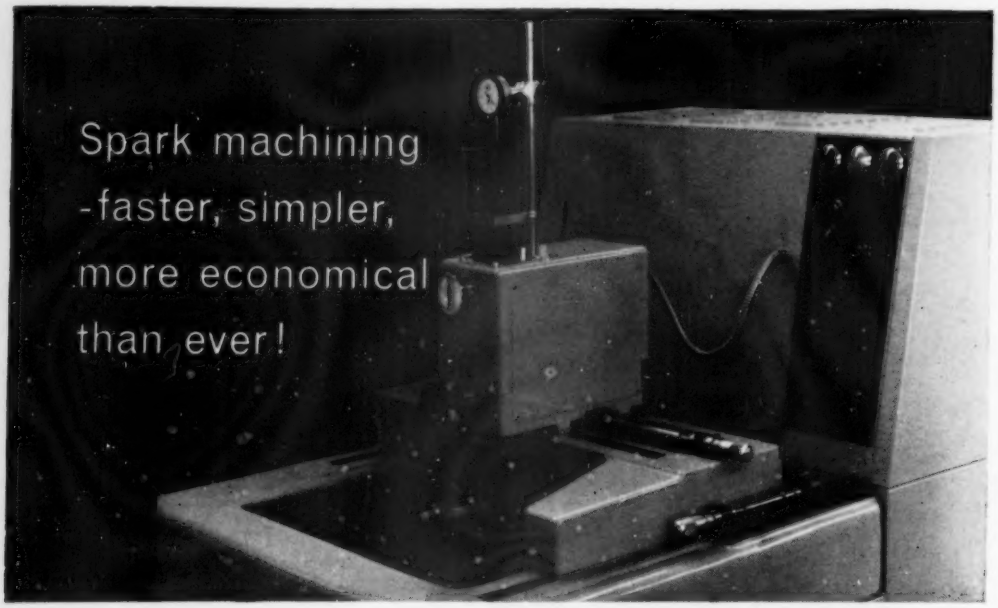

The GKN Spark Machine is faster, more accurate, more versatile

The GKN Spark Machine (Models B1 and B2) gives higher cutting rates, greater accuracy, and—on the B2 machine—a wider range of surface finishes than ever before.

It has all these outstanding features

Both models have a co-ordinate slide movement for rapid electrode positioning; an accurate depth stop; a dial gauge to show forward movement; an alternative work-table for extra paraffin depth.

It is compact and economical

The GKN Spark Machine is well-made, sturdy and compact. All parts of it—work head, electrical equipment and paraffin system—are mounted in the same cabinet. Yet with all these advantages, installation and running costs are low.

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Whether you are engaged in forging, wire-drawing or press-tool making, the GKN Spark Machine is something you should know about. Write to our Sales Agents for the new brochure on:—

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spark machine
DESIGNED BY THE GKN GROUP
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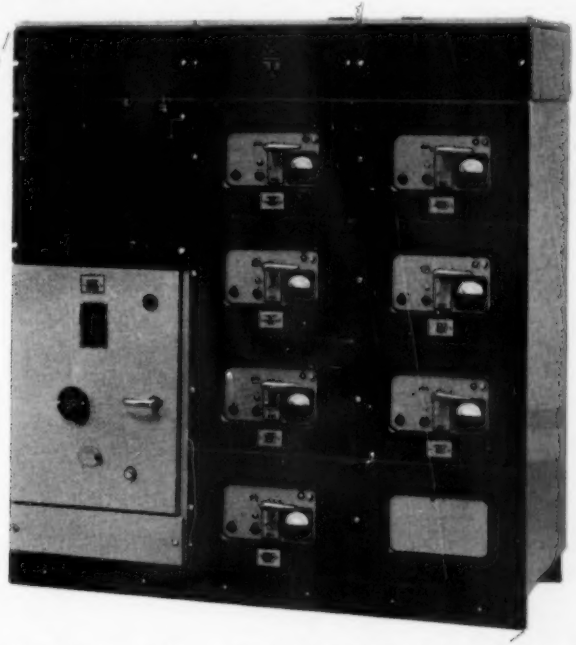
Stelvetite-plastic bonded to steel-has put a new face on Baldwin and Francis Switchgear Panels



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Investigate Stelvetite. It may well save you a small fortune, or a large one.

All enquiries about Baldwin & Francis Switchgear Panels should be made to Baldwin & Francis Ltd., Eyre Street, Sheffield.

Stelvetite

Plastic bonded to Steel

* *Accepted by the Council of Industrial Design for "Design Index".*

STELVETITE*—made in co-operation with BX Plastics Ltd.—by John Summers & Sons Ltd., who produce over 52,000 miles of sheet steel every year. Write to us at Dept. S.M., Shotton, Chester, for full information.

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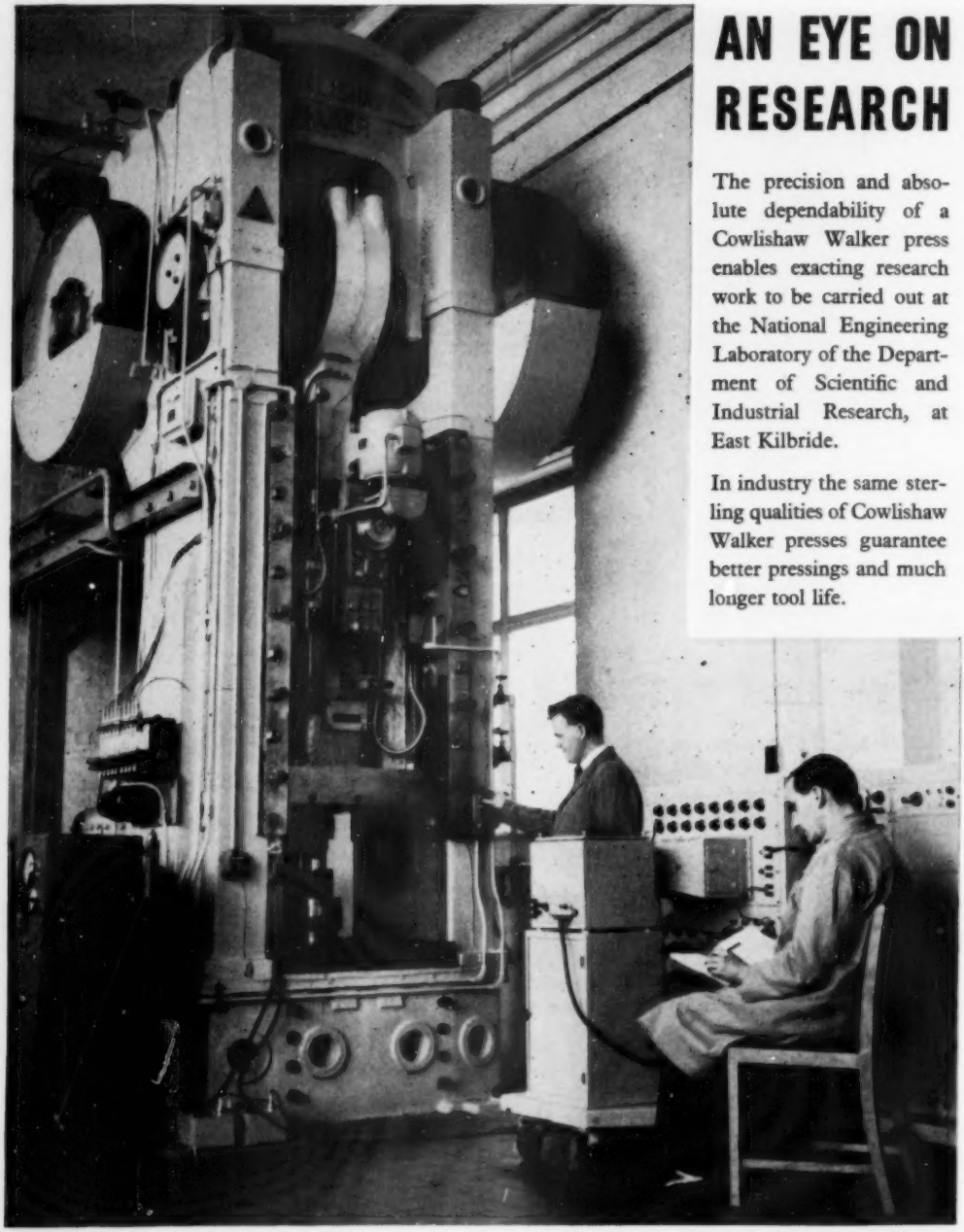

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The precision and absolute dependability of a Cowlishaw Walker press enables exacting research work to be carried out at the National Engineering Laboratory of the Department of Scientific and Industrial Research, at East Kilbride.

In industry the same sterling qualities of Cowlishaw Walker presses guarantee better pressings and much longer tool life.

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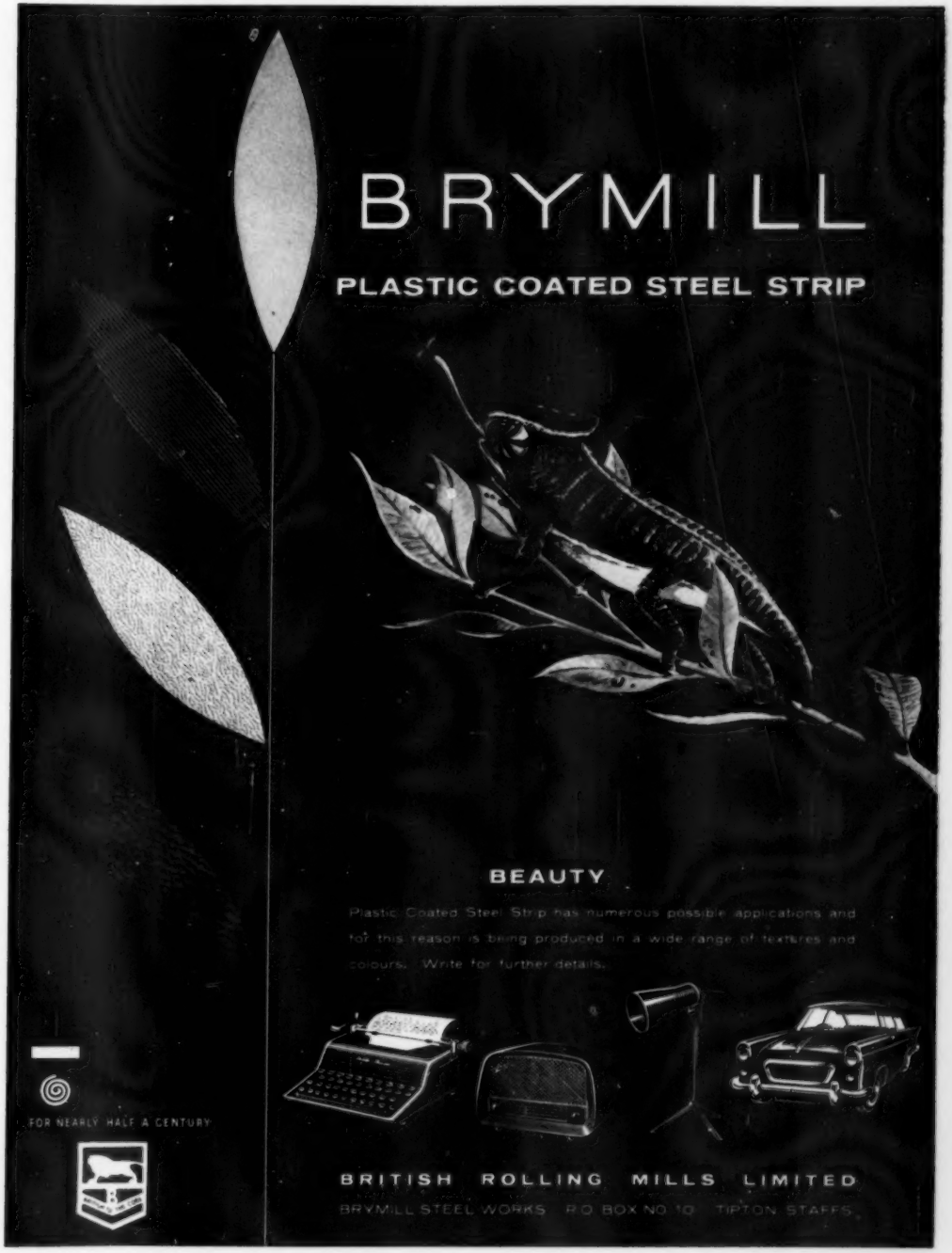
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BEAUTY
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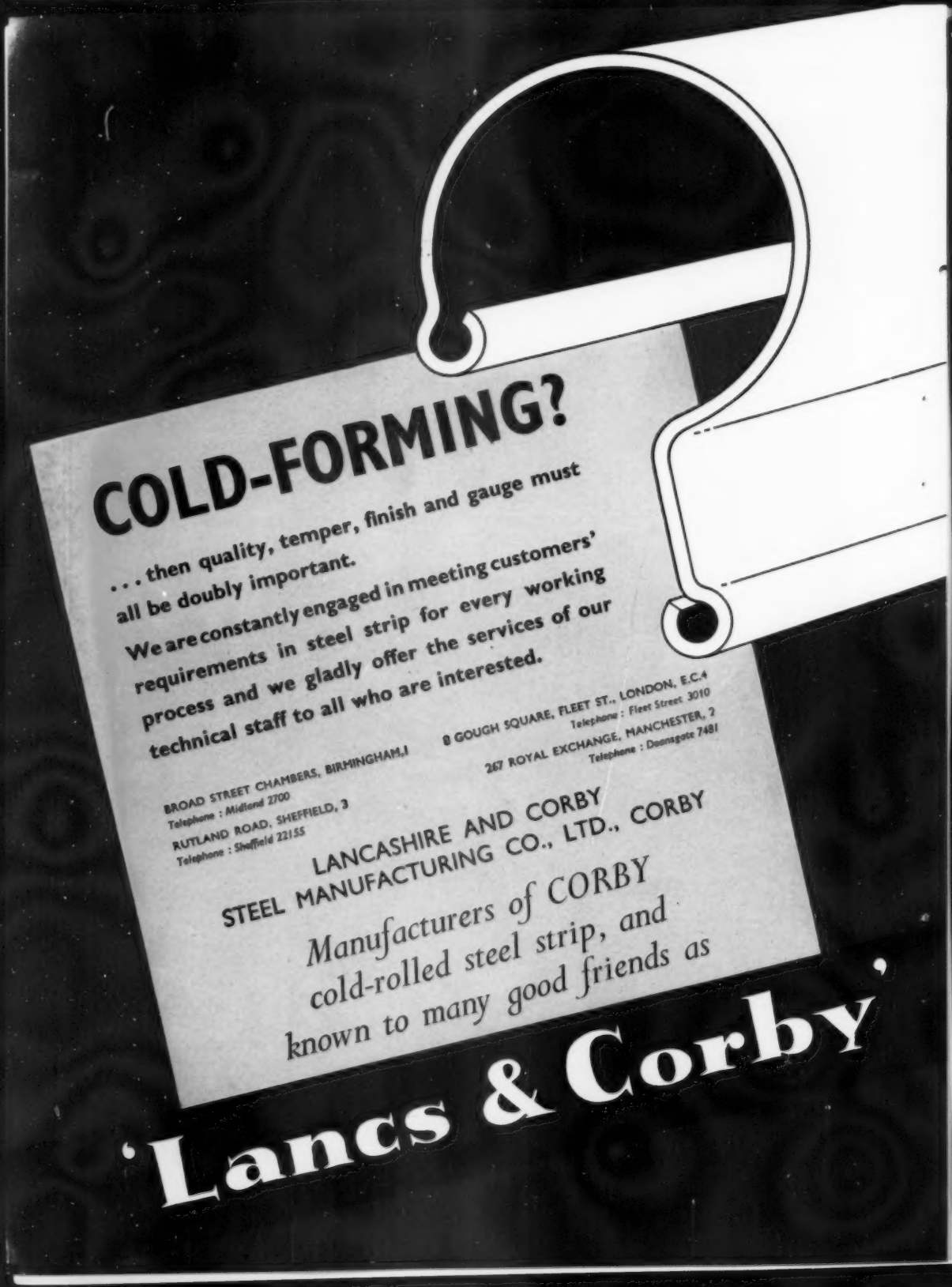
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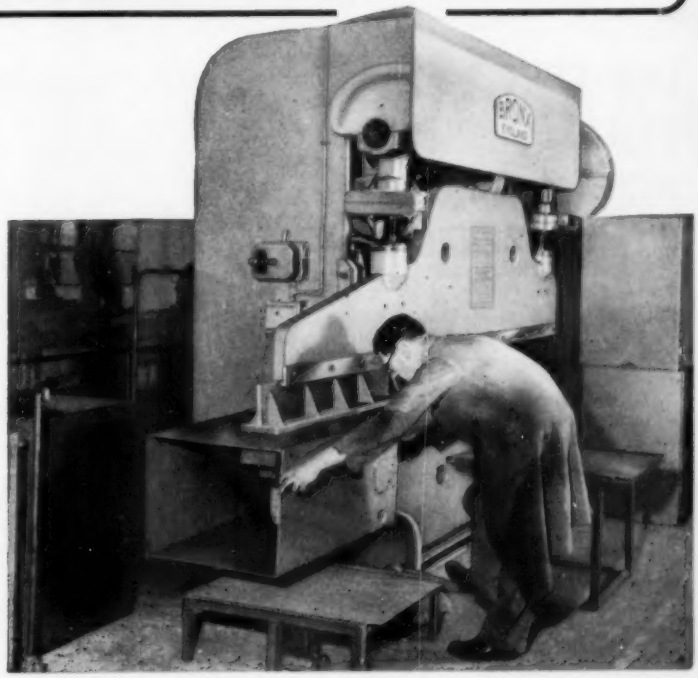
BRONX

Press Brake TOOLS

Seam locking on 22 SWG sheet Spin Dryer bodies



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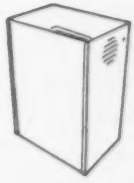
Range of sizes from 10 to 1,000 tons pressure.

Illustration above shows 40-ton Bronx Press Brake (with Horn attachment) at C & C Products Ltd., Merton Abbey, London, S.W., makers of the Drial Major—Spin Dryer. The operation shows seam-locking body-front to body-back.



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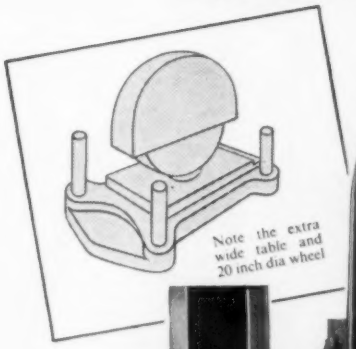
without removing guide pillars



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various sizes available for early delivery

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EXCLUSIVE
HYDRA-COOL
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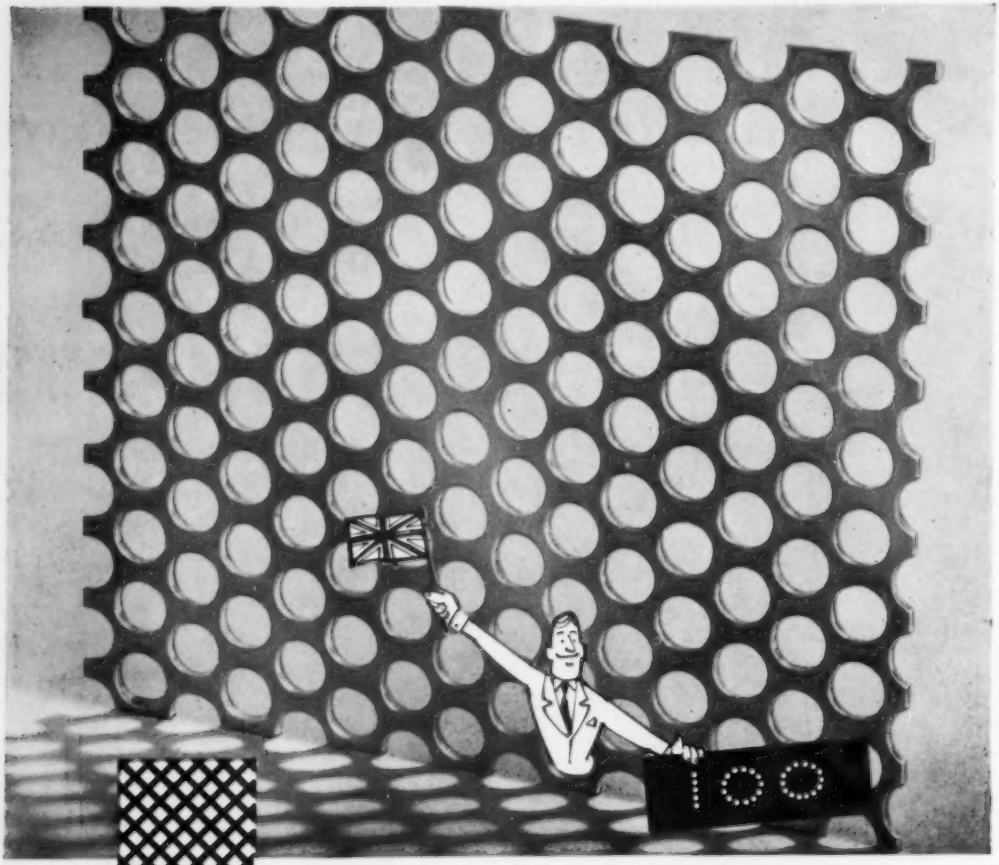
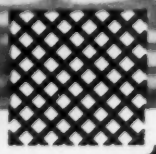
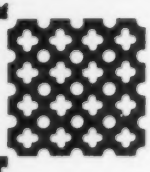
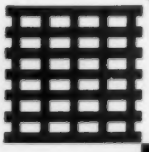
Thompson 5









W. BARNS & SON (HOLLOWAY) LIMITED are proud to announce their hundredth anniversary. They extend thanks to their many clients for valued support in the past and, with the opening of their new extension last year, assure them of continued and even better service in the future.

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PRESS TOOL PUNCHES and SPARK EROSION ELECTRODES

Quickly. Accurately. Easily

THIEL 132

PUNCH SHAPER

Into up-to-the-minute toolrooms now comes the new THIEL 132 profile and punch shaper, with greatly improved performance, and increased earning capacity. Here's what the THIEL 132 accomplishes—quickly, accurately and easily.

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- PRODUCES ELECTRODES FOR SPARK EROSION MACHINES
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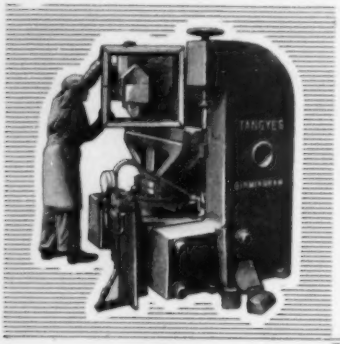


A FOUR-COLUMN DOWN-WORKING PRESS

This is typical of many presses in the high tonnage range. It is 1,000 tons capacity and incorporates various limit switches, volume control valves, time switch and push button control. An automatic cycle can be set in motion which can be pre-set to give a series of speed changes of the stroke as follows:—

(*a*) Fast Approach period; (*b*) Slow-down period; (*c*) Pressure build-up period; (*d*) Dwell period, holding the pressure.

At the completion of this pre-set cycle the ram returns rapidly to top position ready for next cycle which is commenced at the touch of a button.

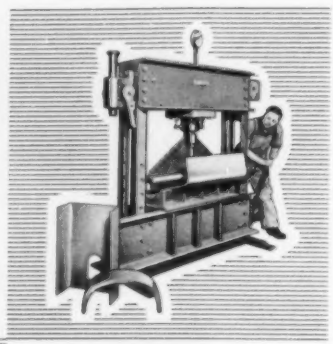
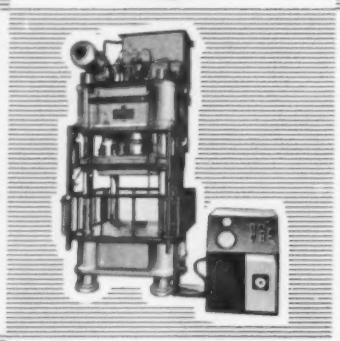


PLATE BENDING PRESS FOR BOX-SHAPE

The principal feature of this press is its balanced swinging head. This enables a box form to be completed after which the head is swung out of line with the frame to allow for the removal of the workpiece. This example is 100 tons capacity, is powered by one ram and accommodates up to 48 in. plate. Additional rams are used in accordance with tonnage required and width of plate. Details of various presses already developed can be supplied upon receipt of specific enquiries.



A GENERAL SERVICE PRESS

Most Tangye presses are tailored to suit a customer's particular needs but this is an example of one of the standard lines. It is available in 70 or 90 tons capacity (Brit. Tons.) and is of girder frame construction. Open sides allow any length to be accommodated up to 10 in. width and it is suitable not only for heavy general service purposes but its precisely controlled hydraulic power makes it equally effective for extremely delicate work. Daylight is adjustable from zero to 23½ in. and width accommodated is 48 in. between uprights. Power is supplied by a Tangye double-plunger type hand-pump but a motorised unit can be supplied.

PLATE BENDING PRESS

This type of press is supplied in a variety of lengths and capacities. The one shown is 40 tons power and accommodates ¼ in. plate 6 ft. wide. It has 3 in. daylight and tools and a 6 in. stroke, power is provided by a high-speed pump.

A single ram machine is supplied for plates up to 4 ft. wide and additional rams are added in accordance with size of plate and power required. In bending machines it is not only the gauge of plate but also the width of "V" opening on the tool which determines the power required.

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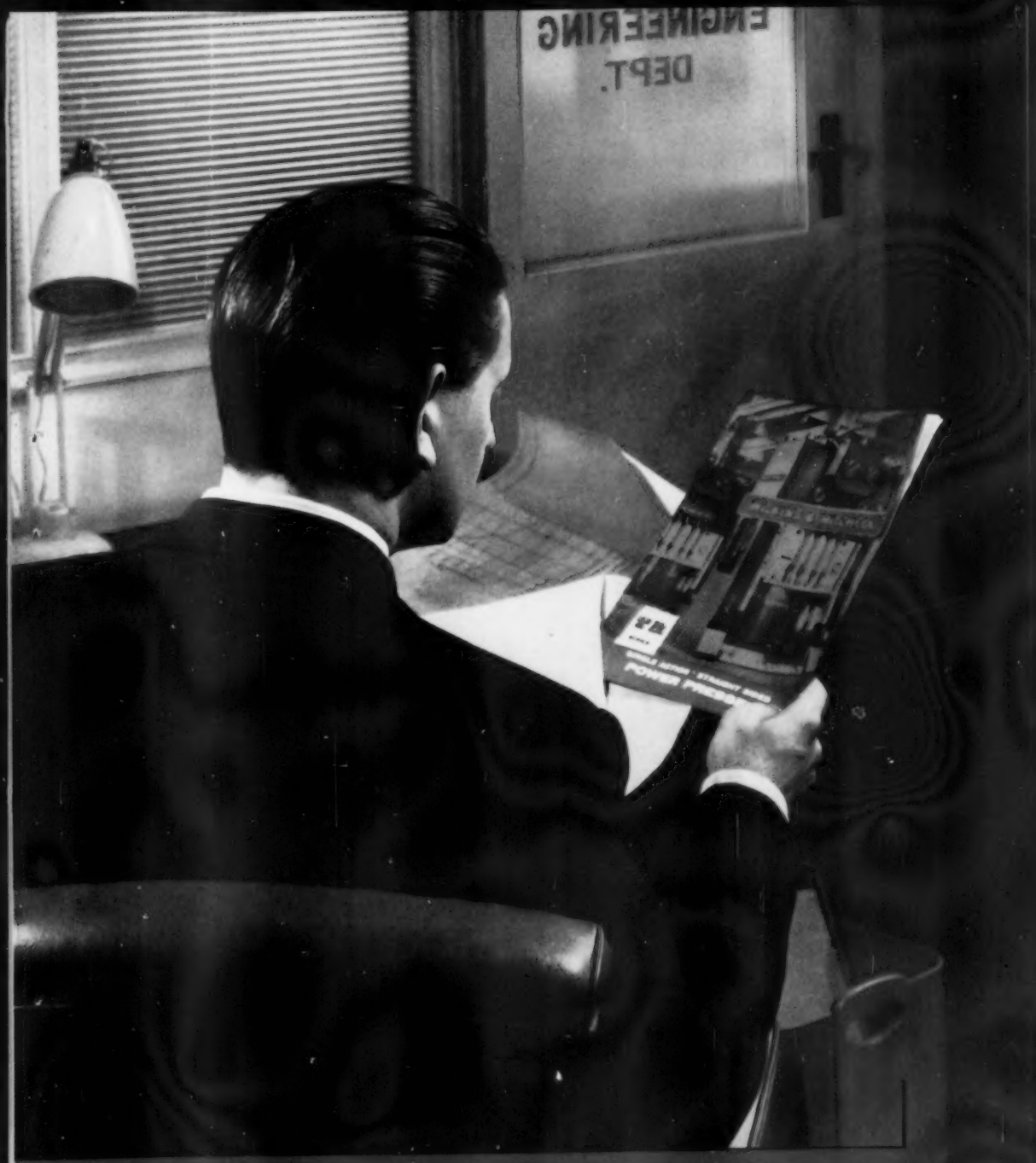

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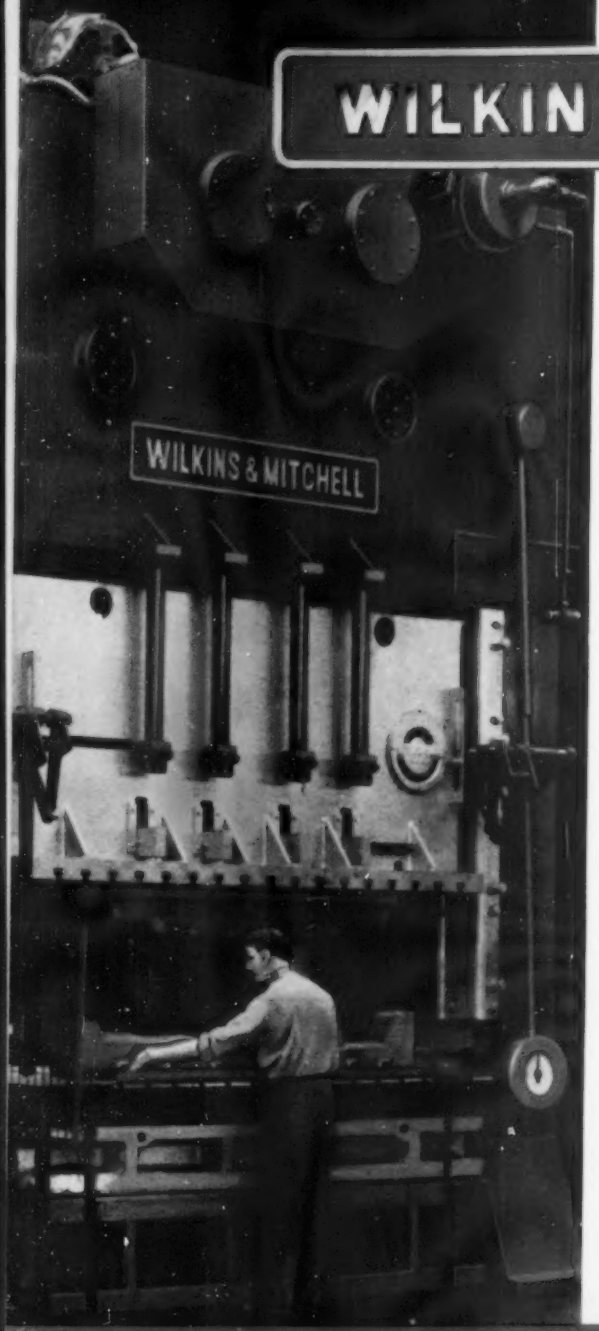

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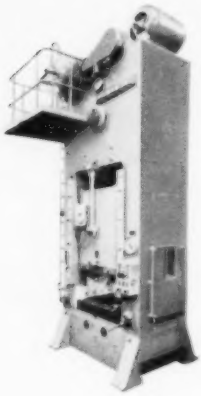

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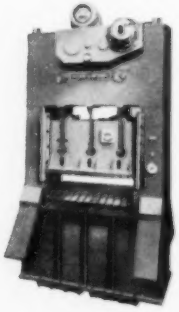

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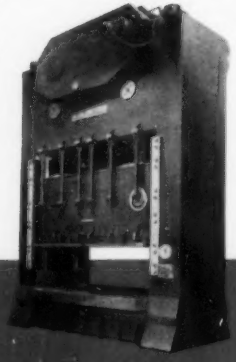

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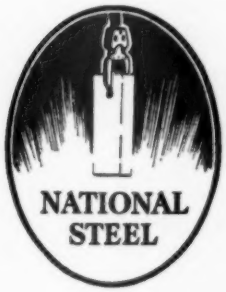

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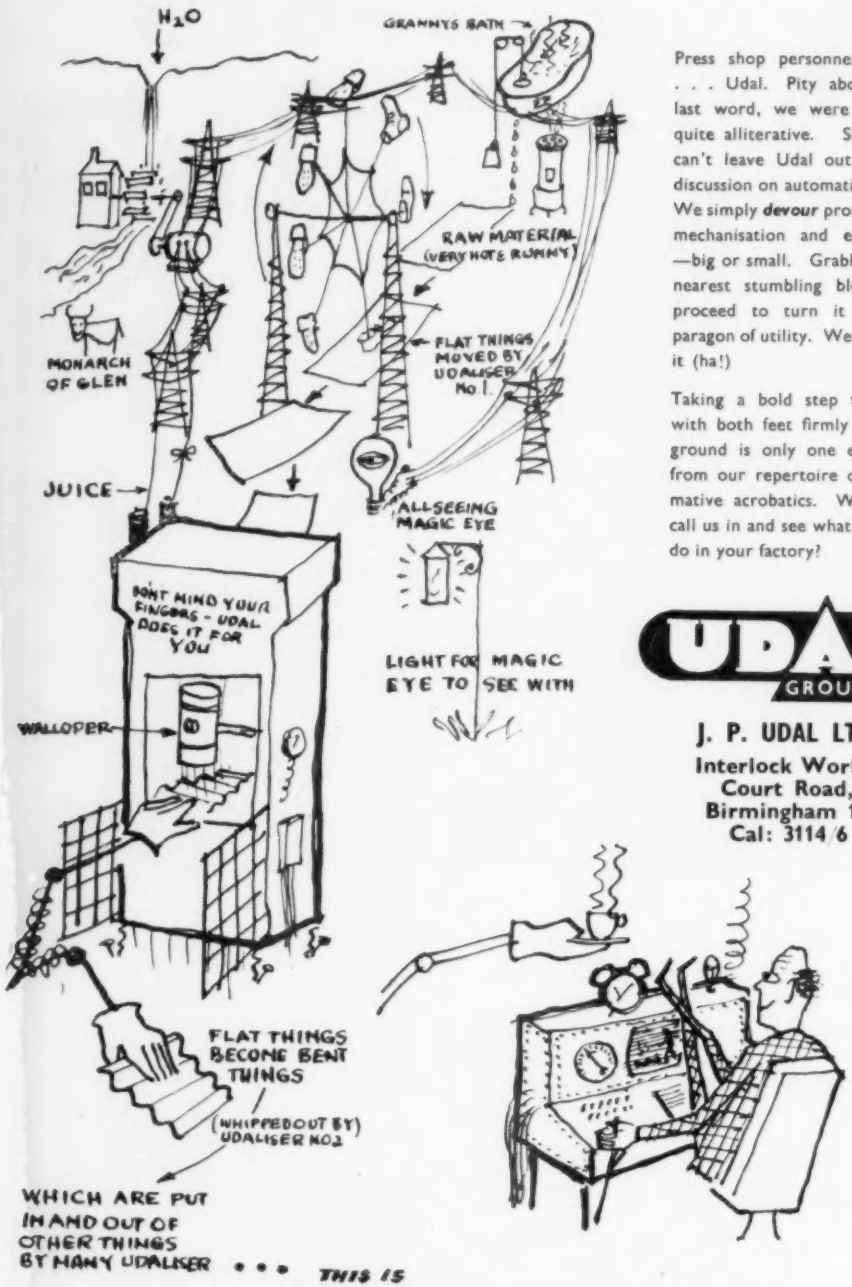
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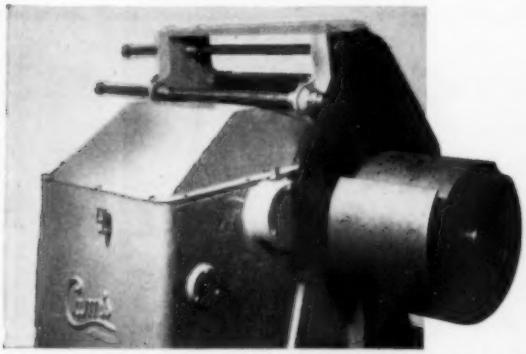

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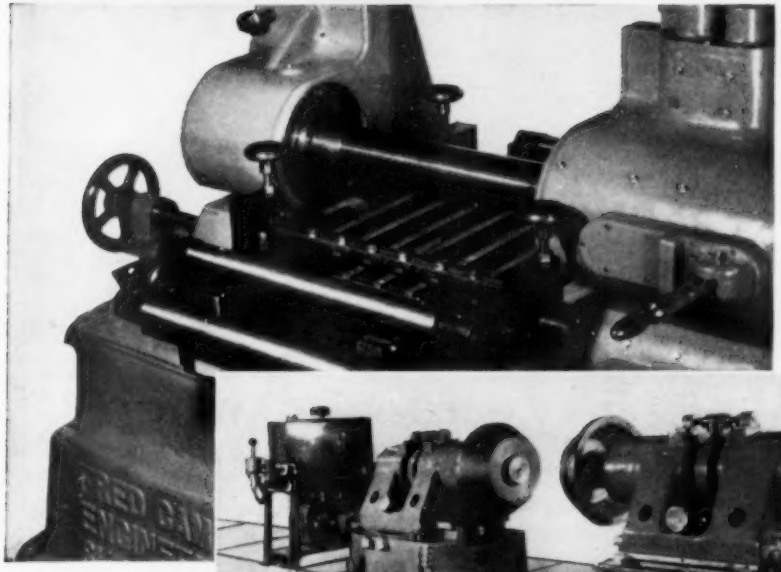

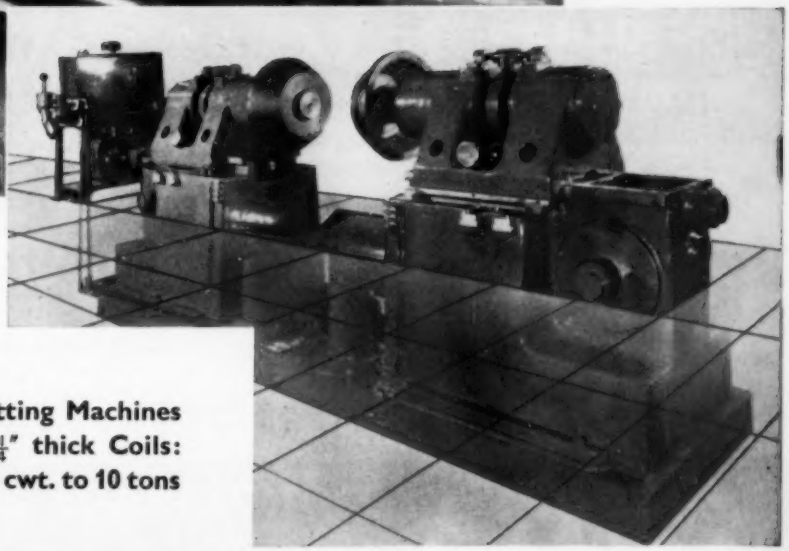

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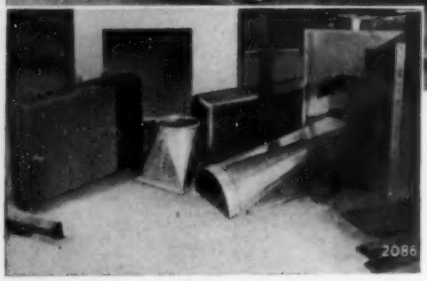

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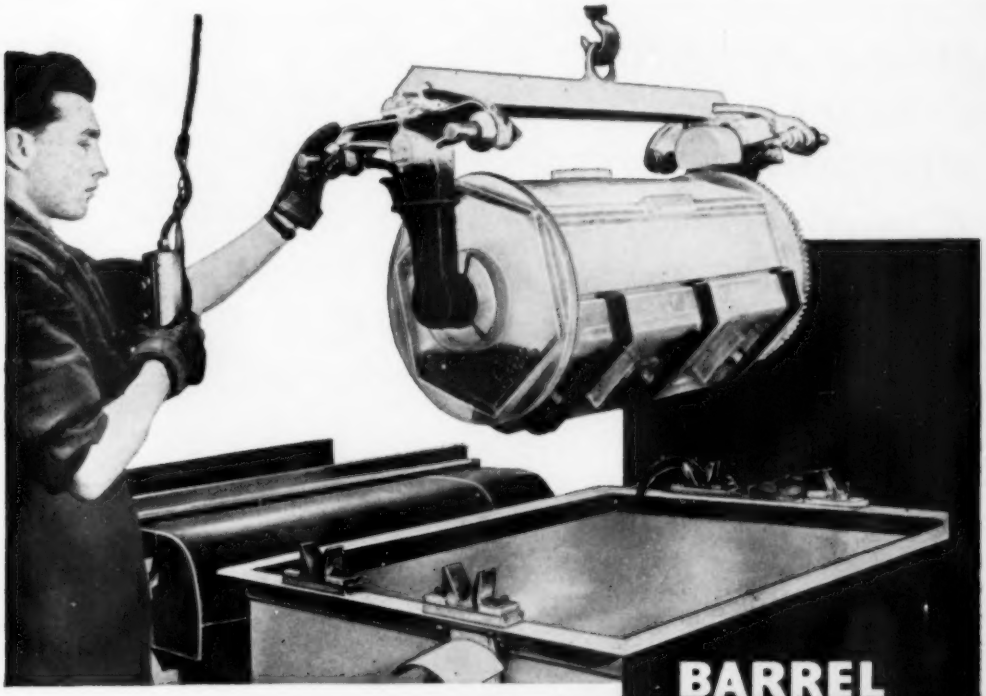

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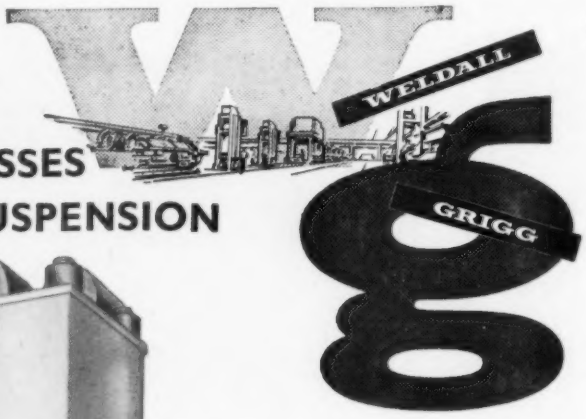

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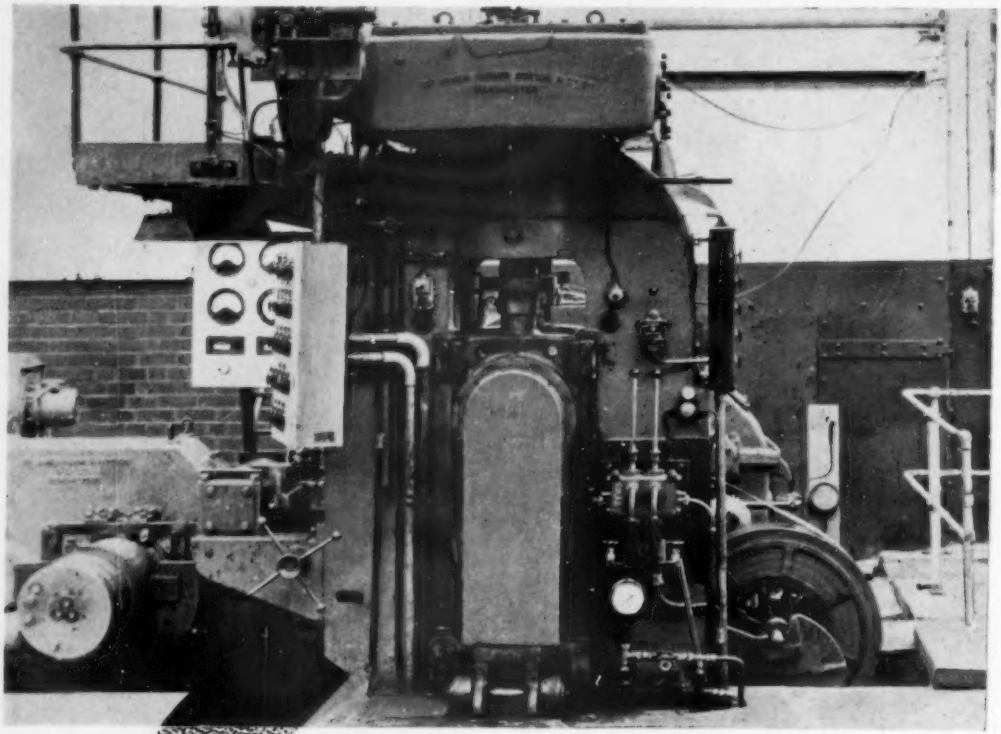

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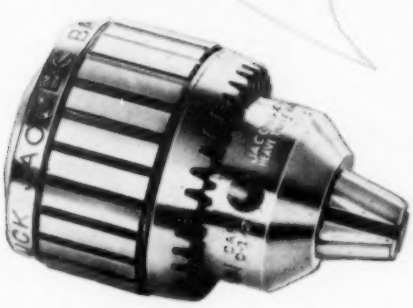

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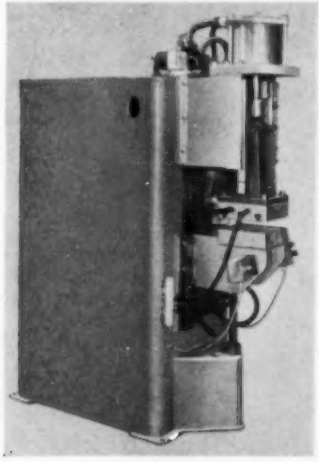

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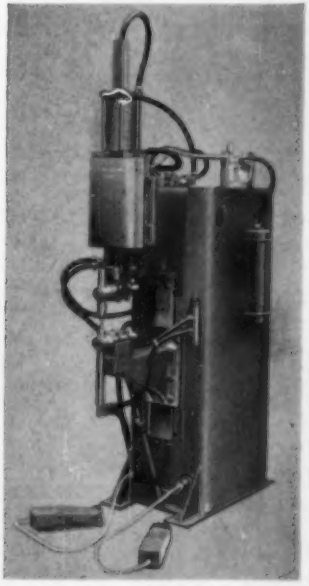

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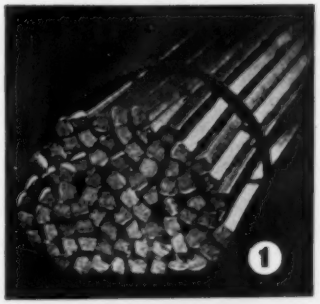

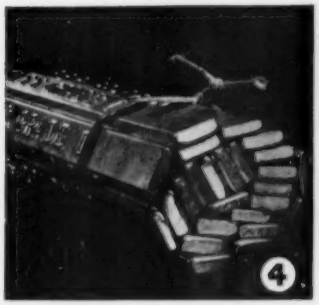

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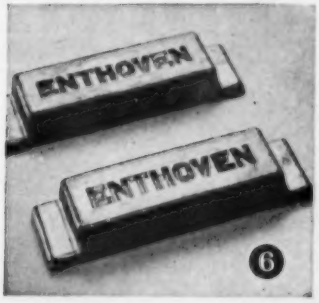

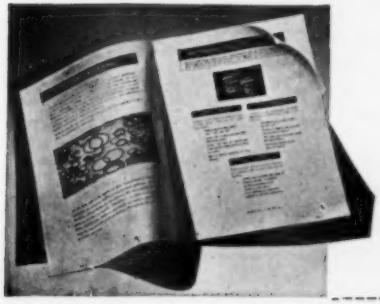

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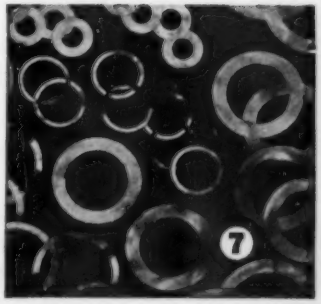

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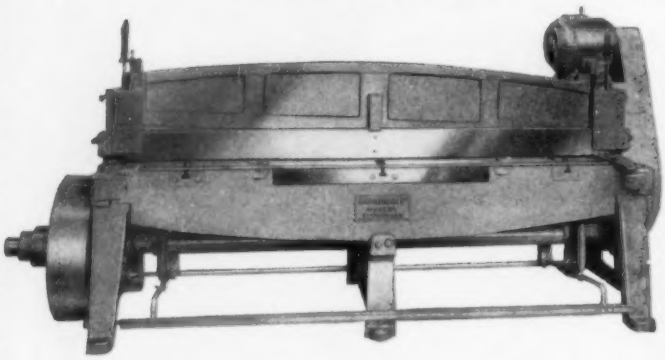

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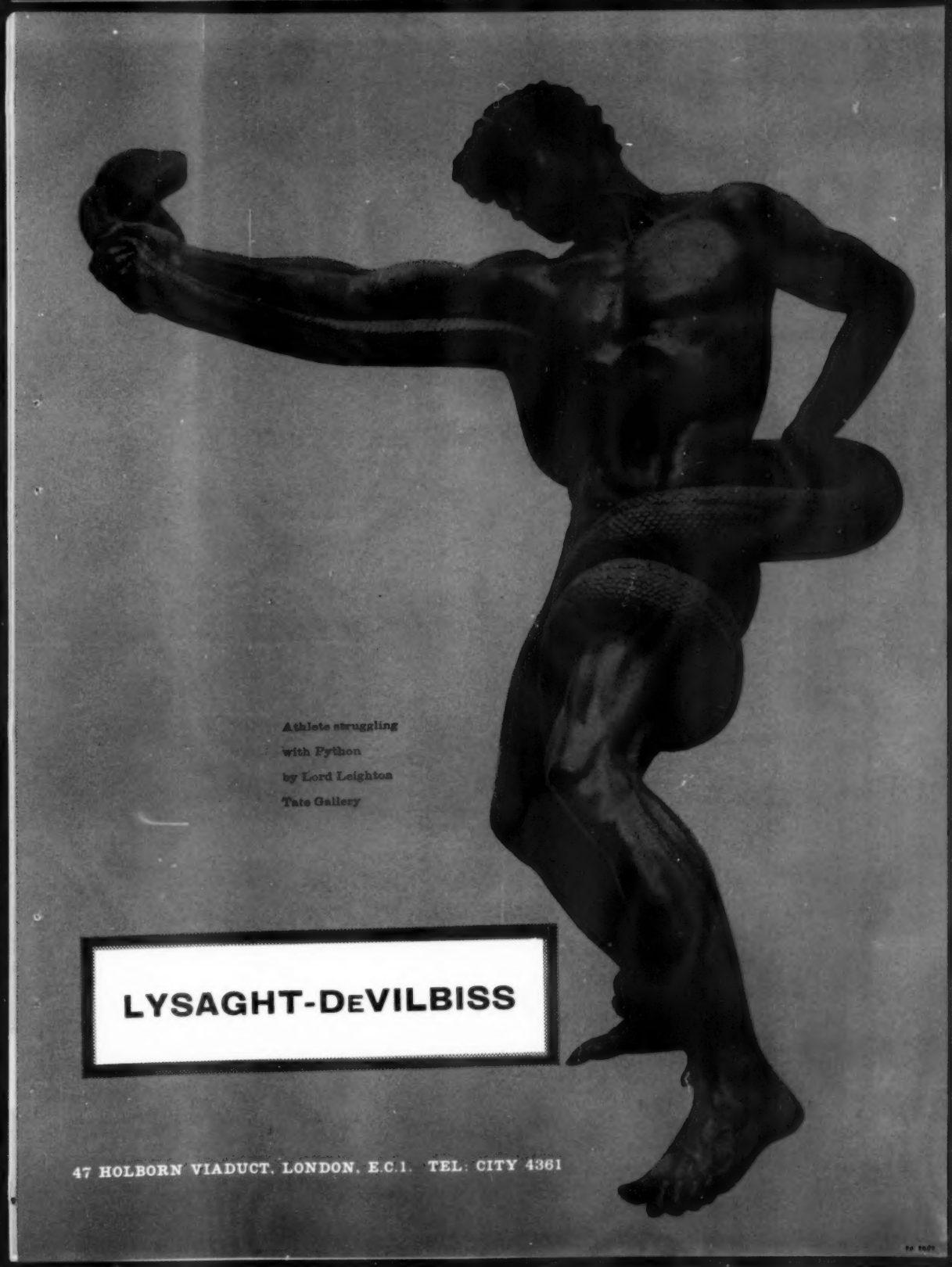

Athlete struggling
with Python
by Lord Leighton
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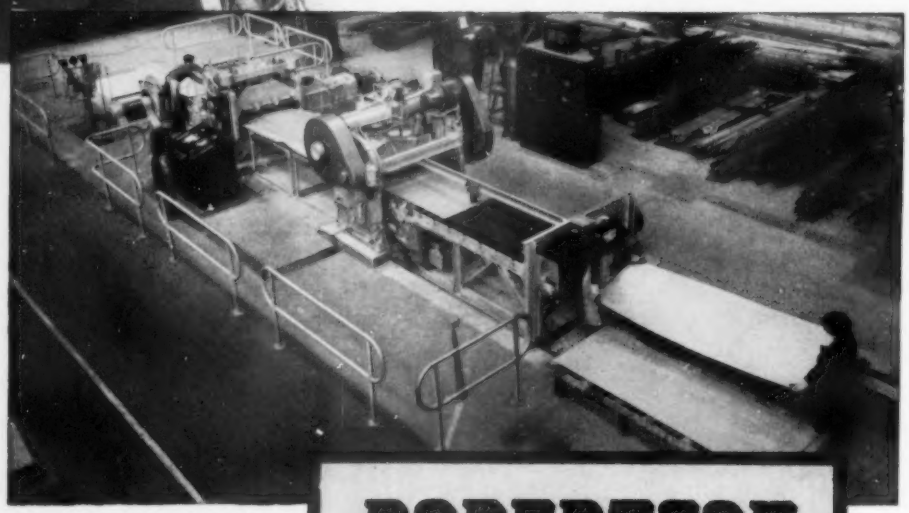

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A similar plant has been supplied to Firth-Vickers Stainless Steels Ltd., for the Shepcote Lane Warehouse.

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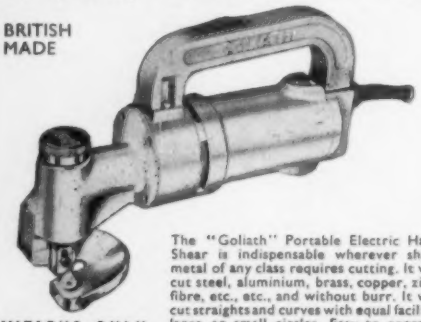

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CCW

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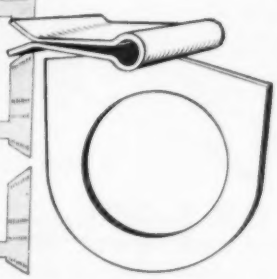

CCW provides a notable combination of hardness and toughness making it an excellent shock-resisting tool steel for cold punching work. Amongst its many uses are press and forming tools, dies and rings for the production of metal containers, casement tools for mild steel and cold heading dies.

A useful degree of red hardness at elevated temperatures has led to CCW being used also for hot heading dies, forming and piercing tools and purposes where short contact with hot metal involves only restricted rise in tool temperature. Very clear printed data on this steel is available upon request.

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Dies and rings for metal containers
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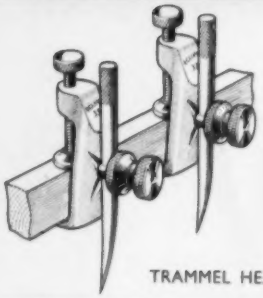
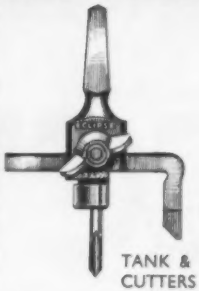


TRAMMEL HEADS



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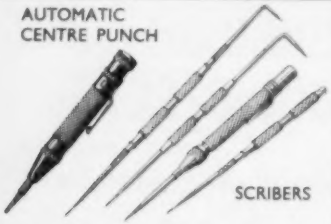

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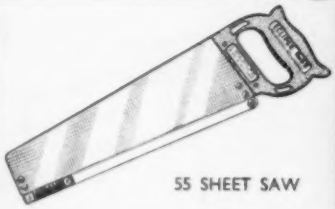

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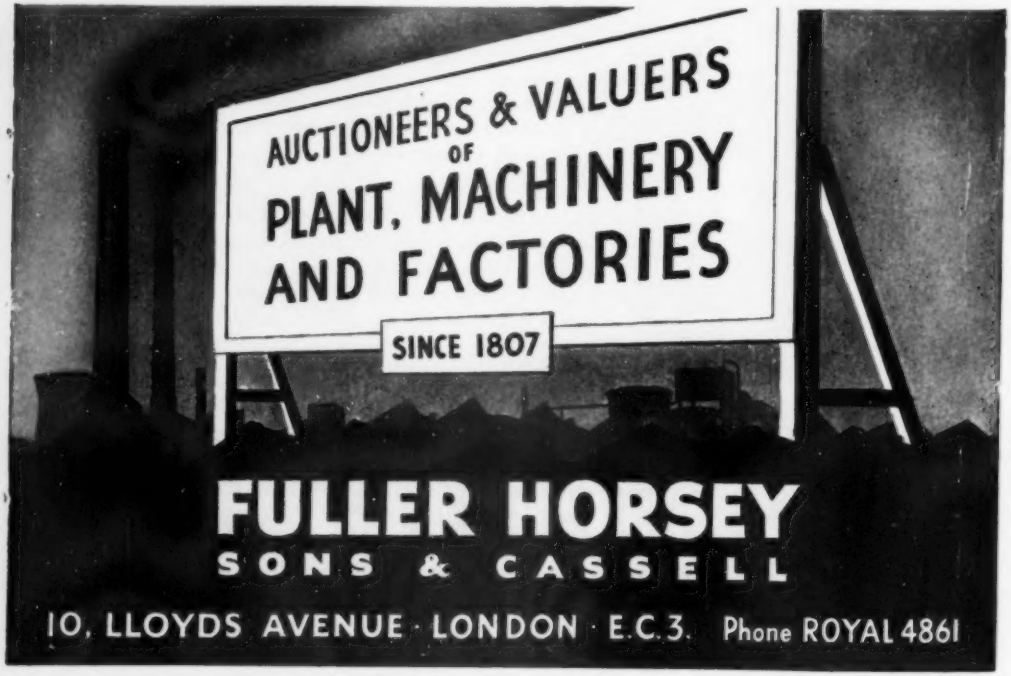

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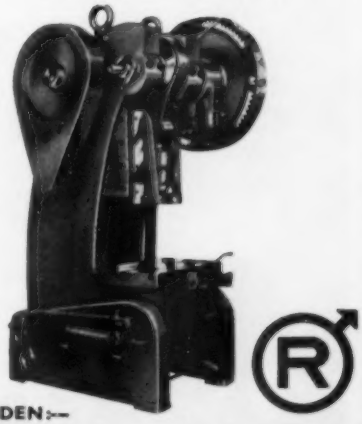

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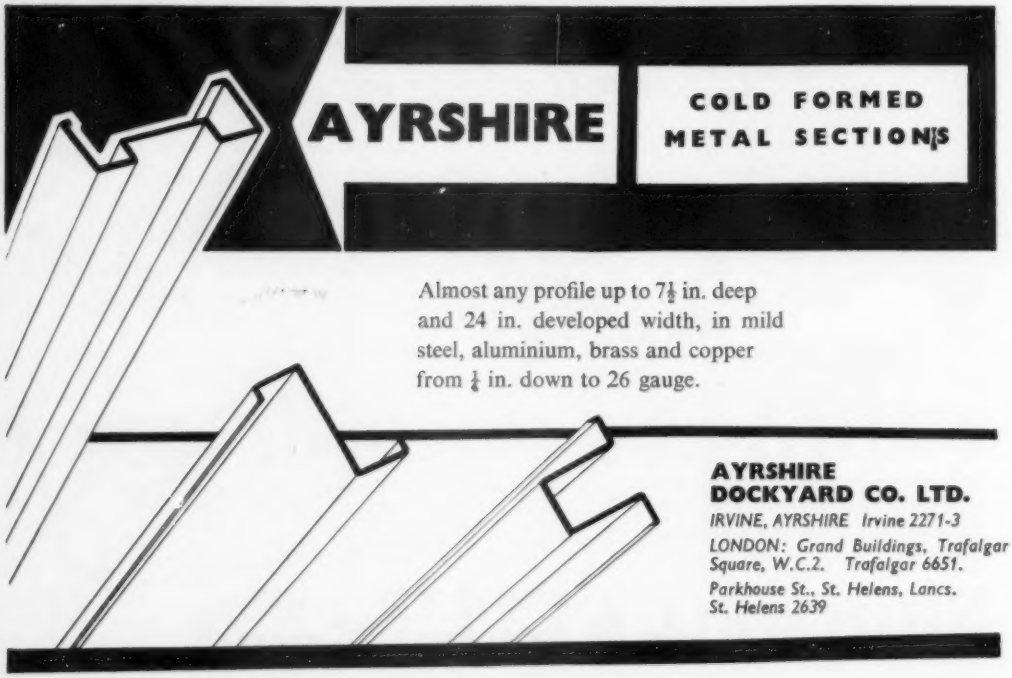
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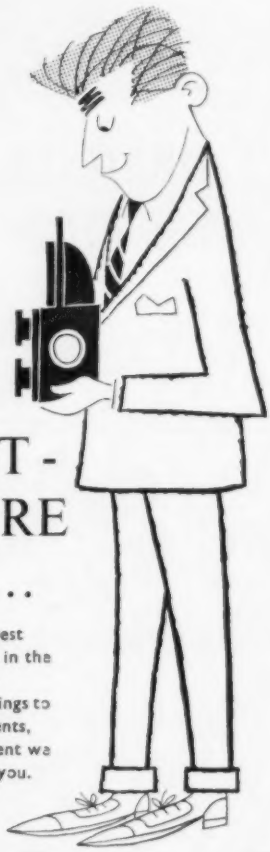

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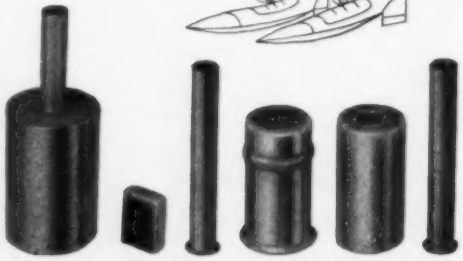

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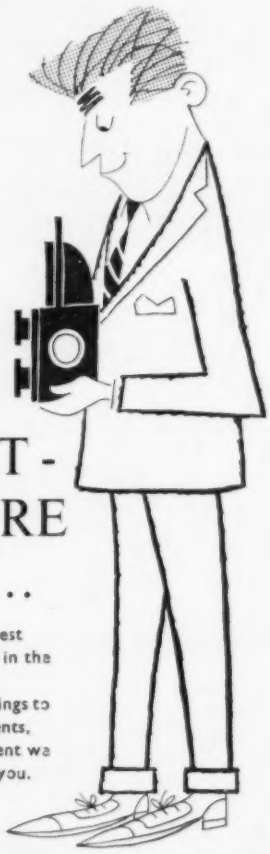

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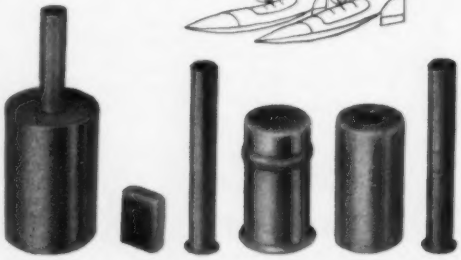

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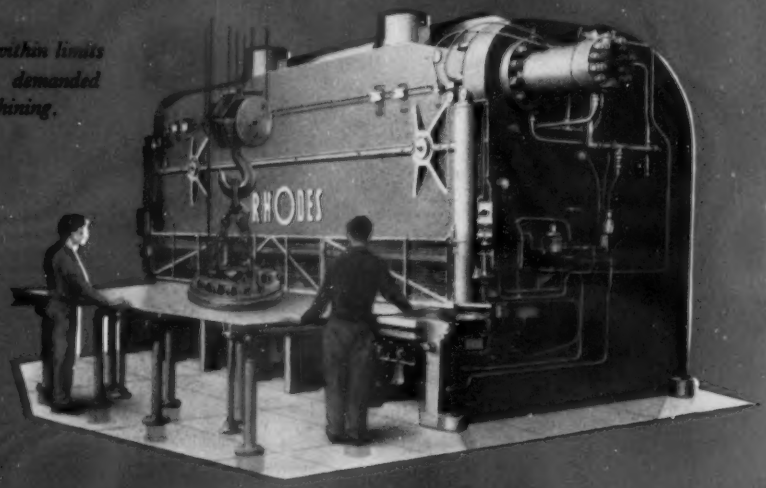

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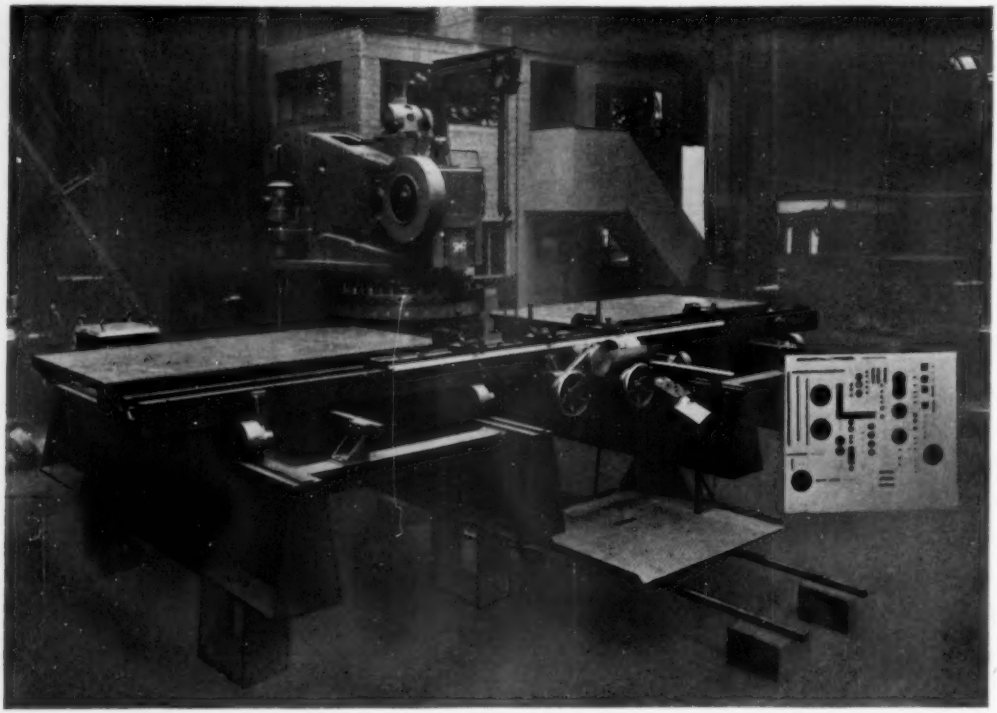

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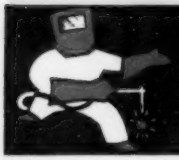

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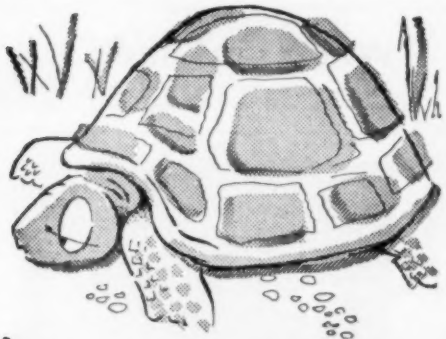

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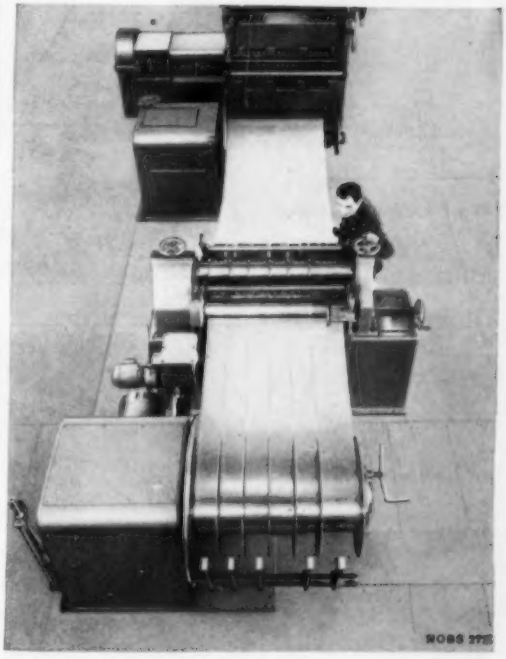

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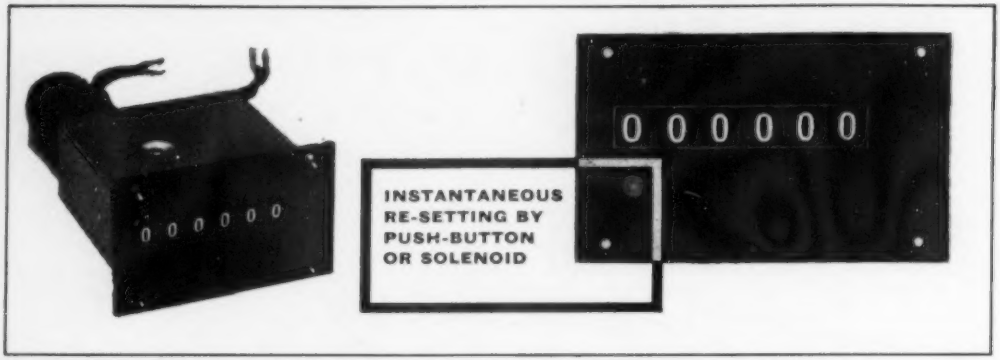

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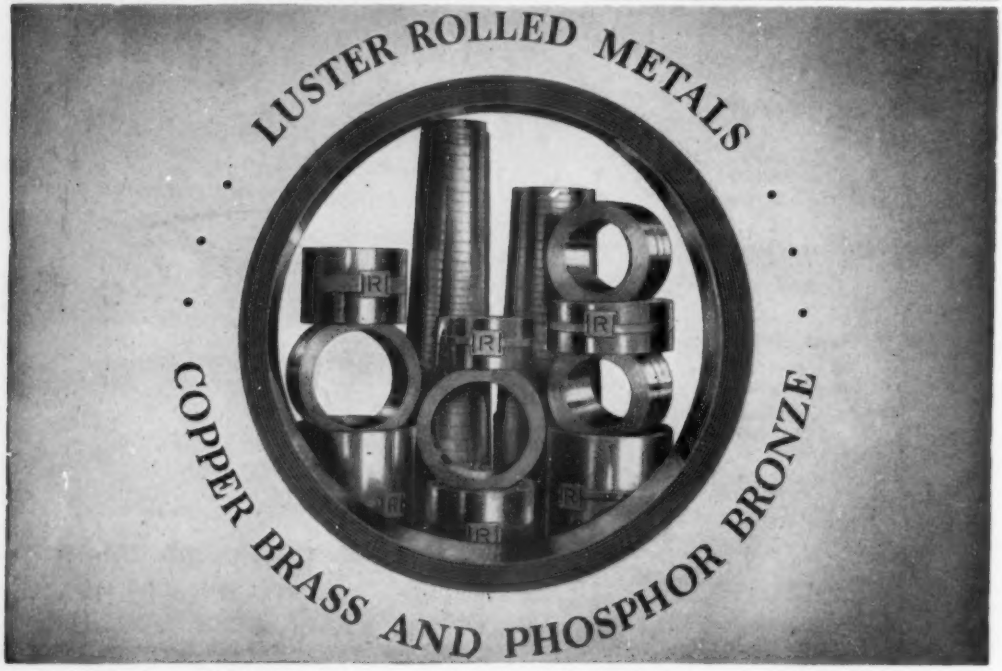

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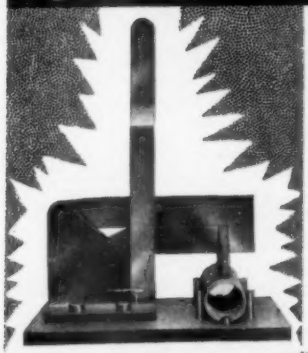

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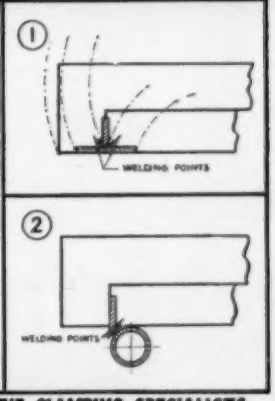

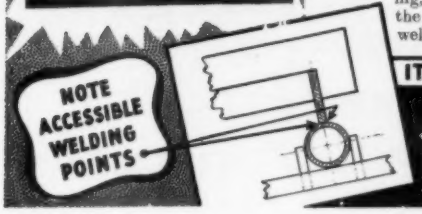

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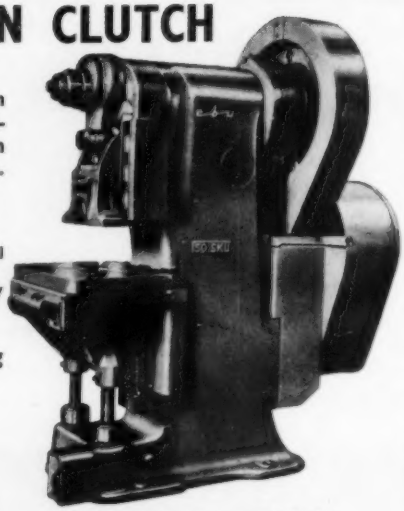

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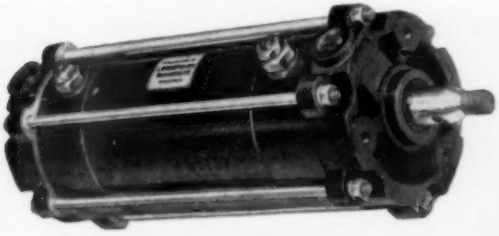

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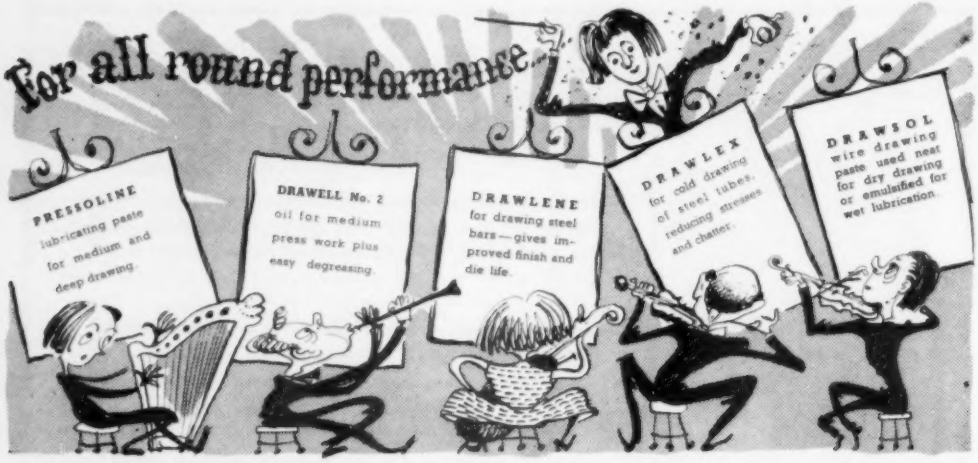
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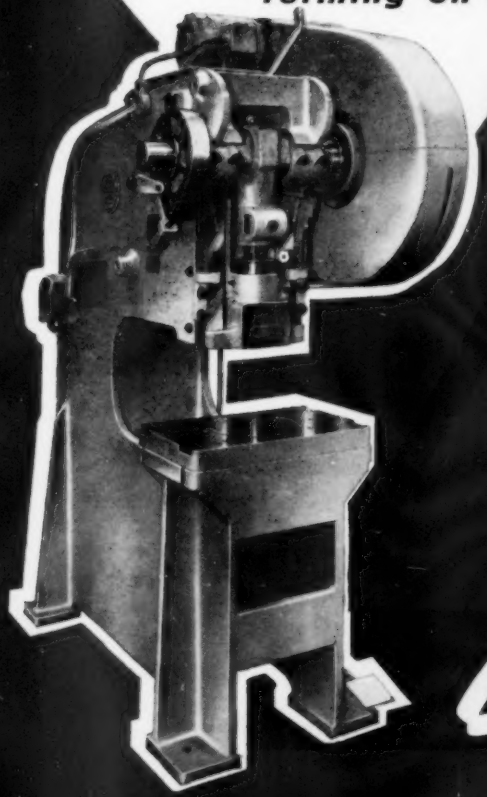

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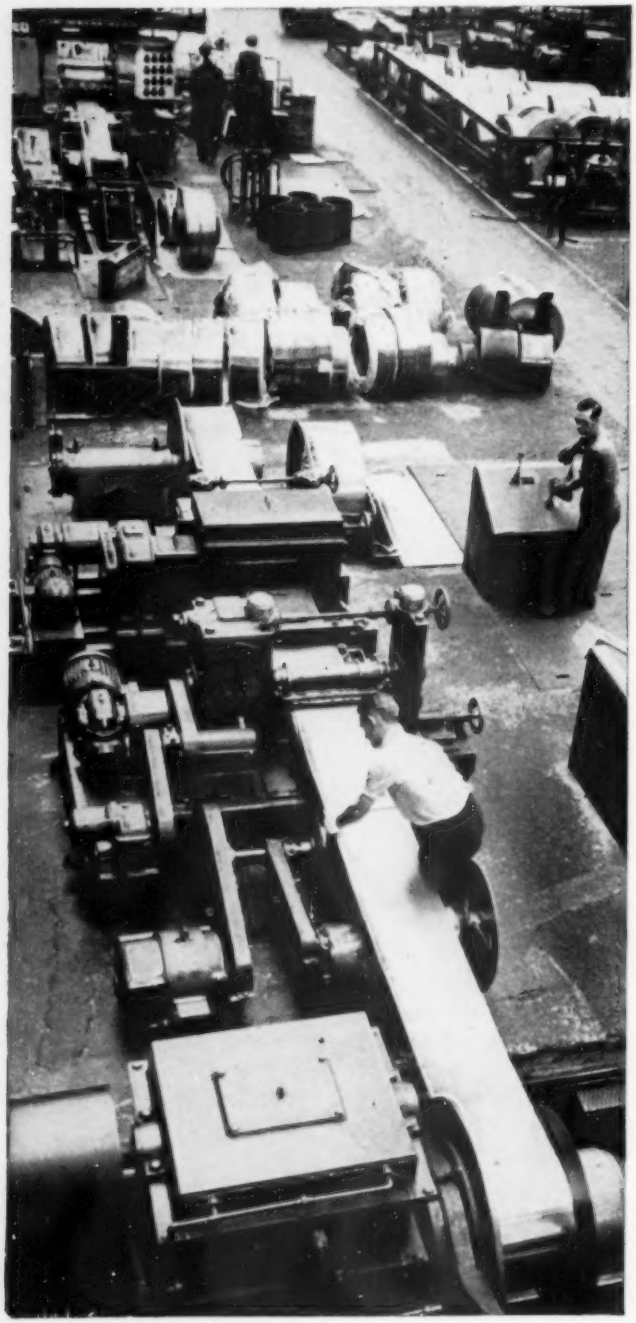

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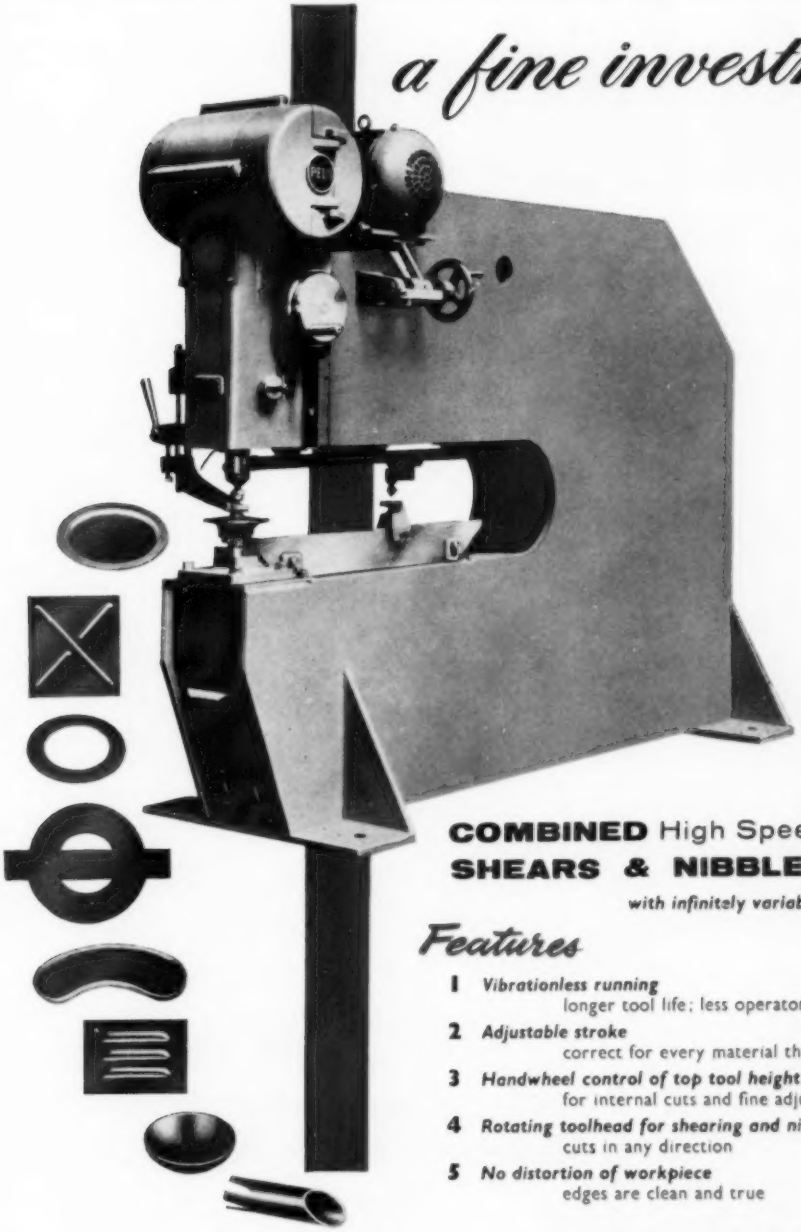

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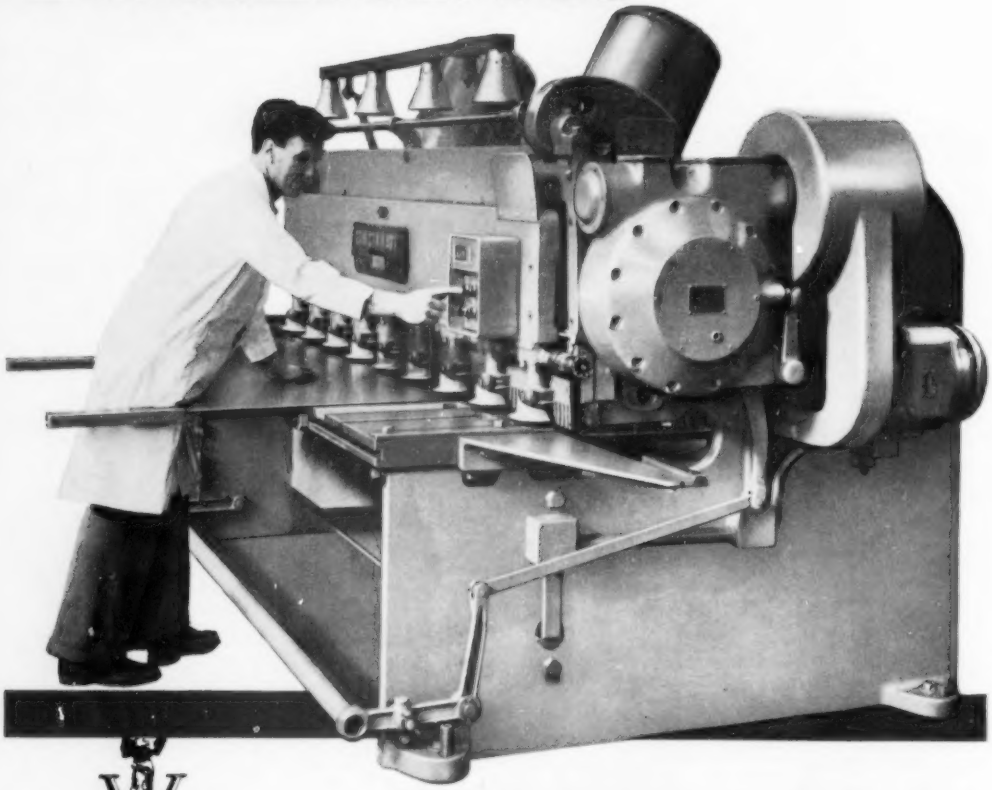

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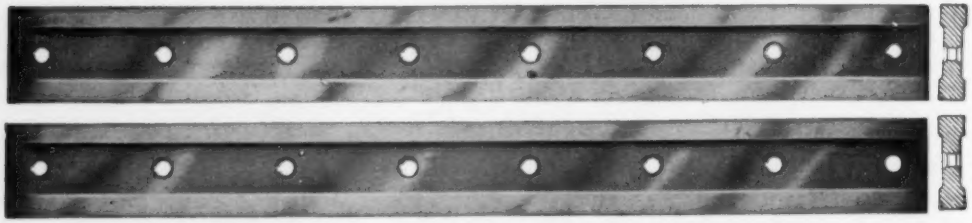

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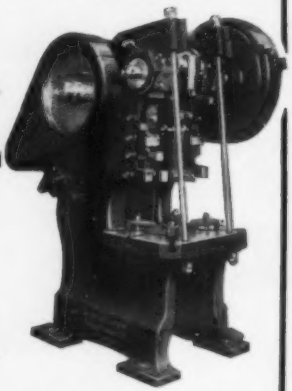

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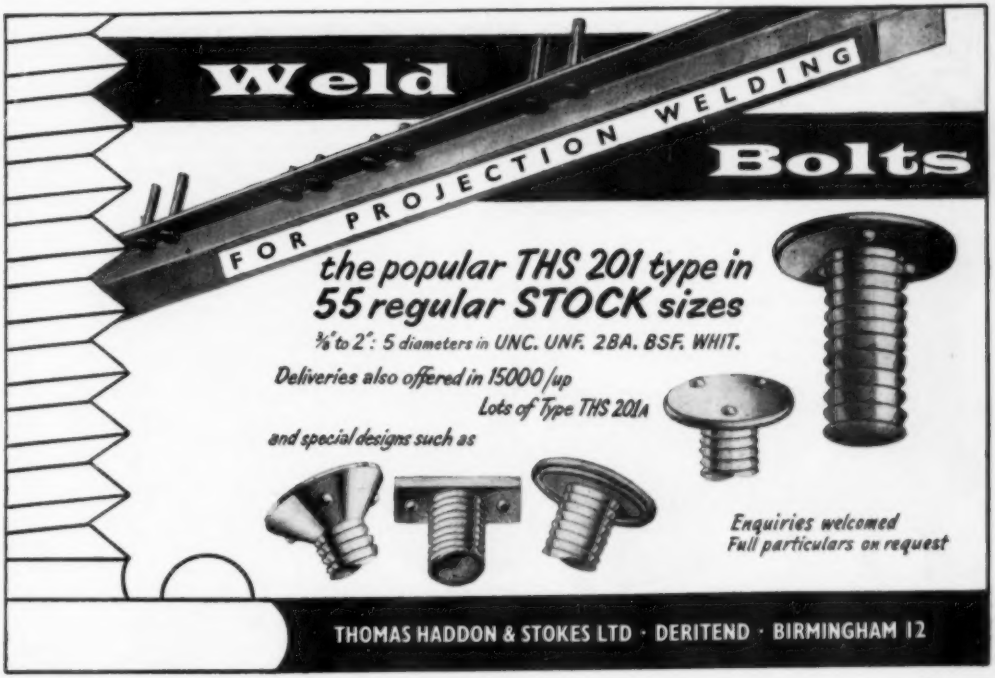
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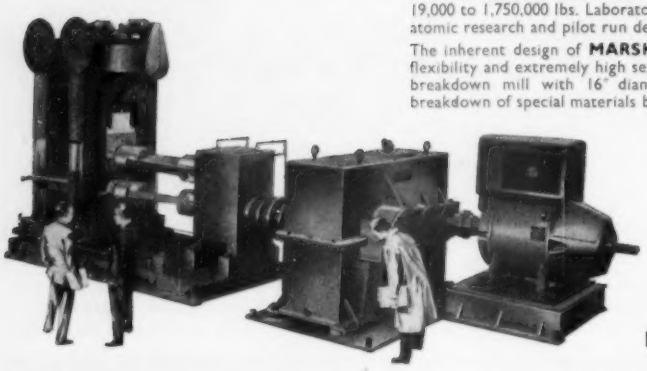
MARSHALL RICHARDS manufacture a complete line of precision engineered Rolling Mills for rolling ferrous and non-ferrous metal, including the newest alloys, in sheet, strip, wire or rod. There is a wide range of sizes and types for practically every rolling need, from heavy breakdown to high speed wire flattening. The mills incorporate work rolls from 3" to 20" diameter with maximum separating force at 100 FPM from 19,000 to 1,750,000 lbs. Laboratory models are widely used in metallurgy, atomic research and pilot run development.

The inherent design of **MARSHALL RICHARDS** mills achieves great flexibility and extremely high separating force. Illustrated is a heavy duty breakdown mill with 16" diameter rolls, used for the initial heavy breakdown of special materials by a leading producer.



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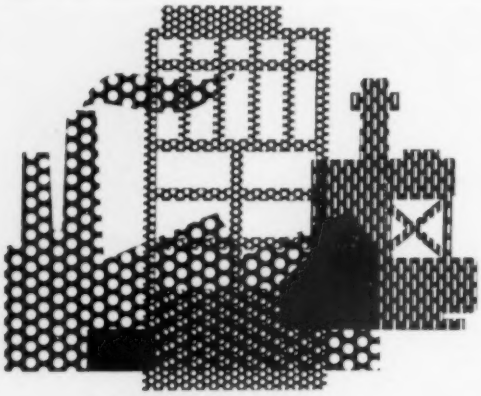

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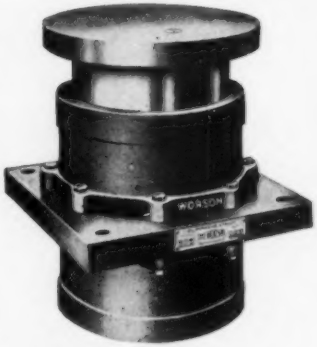

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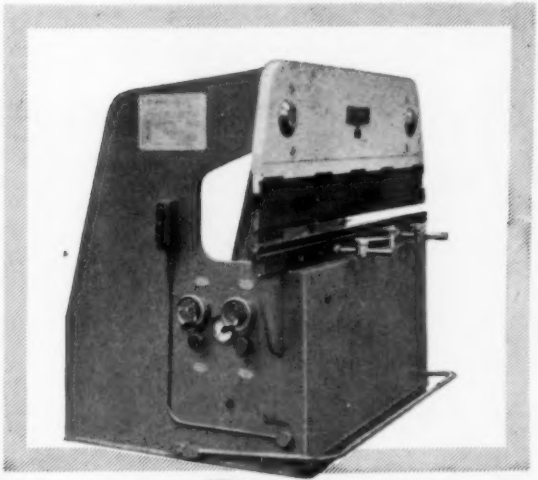

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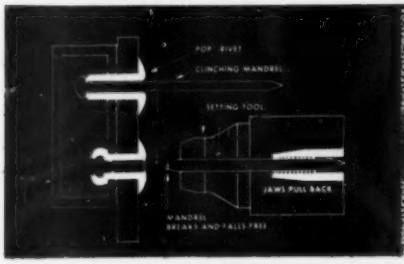
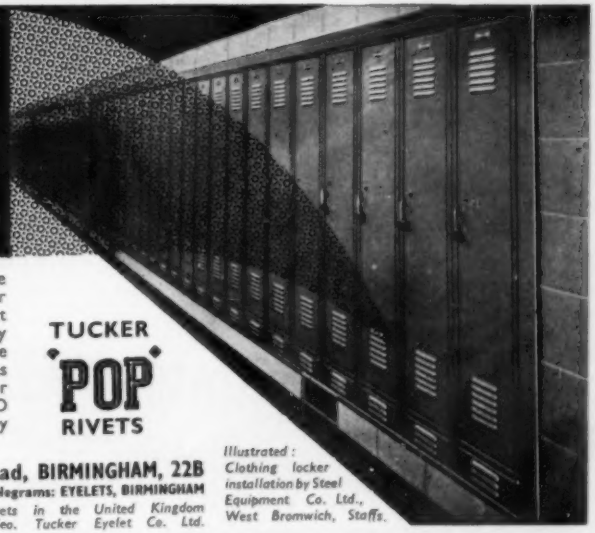
For faster fastening in sheet metal assemblies





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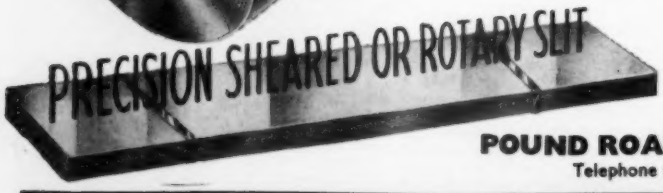

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SUMMERS "GALVATITE" EX STOCK. TO YOUR WIDTH, IN COILS OR LENGTHS

BOTH BRITAIN'S NEW HOT STRIP MILLS ARE BEING BUILT BY DAVY-UNITED

The famous Hot Strip Mill at the Ebbw Vale Works of Richard Thomas & Baldwins Limited the first in Europe, which Davy-United also helped to build. This photograph shows the mill at the completion of an extensive modernisation scheme in August, 1959, after nearly 21 years of continuous production

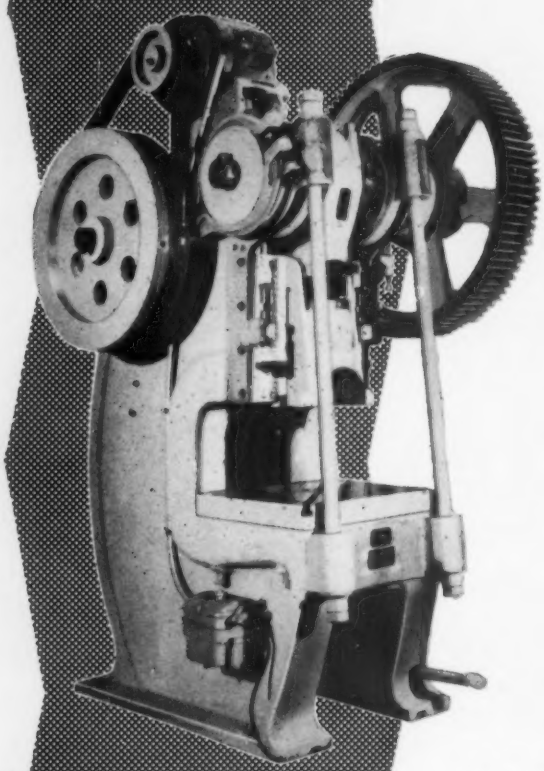
Two new Hot Strip Mills are now being built in Britain—the first at the Ravenscraig Works of Colvilles Limited: the second at the Spencer Works at Newport, Mon., of Richard Thomas and Baldwins Limited. Davy-United have been entrusted with the building of both of them.

DAVY-UNITED

370/DU

Davy and United Engineering Company Limited, Sheffield, England.

Open-fronted presses



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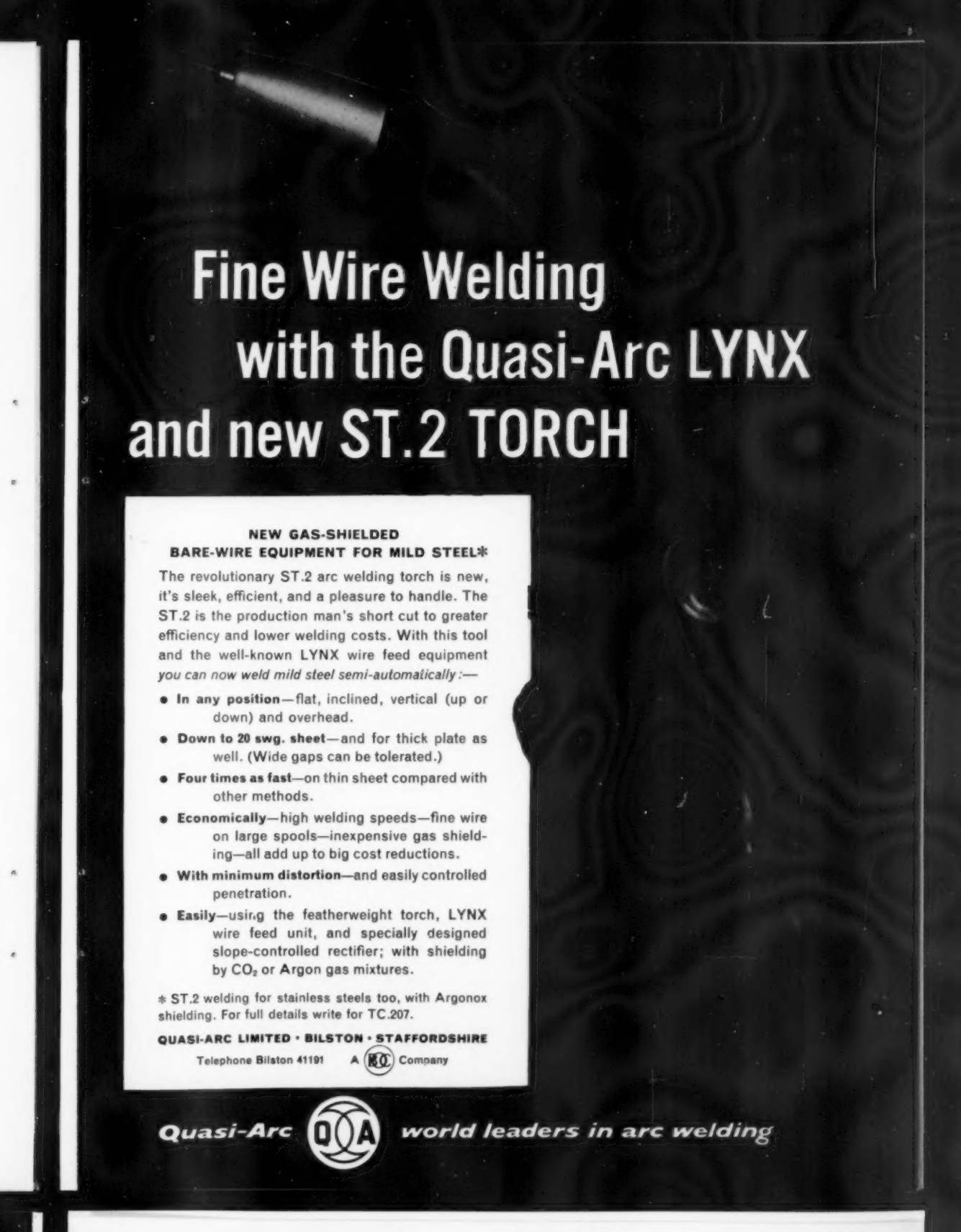
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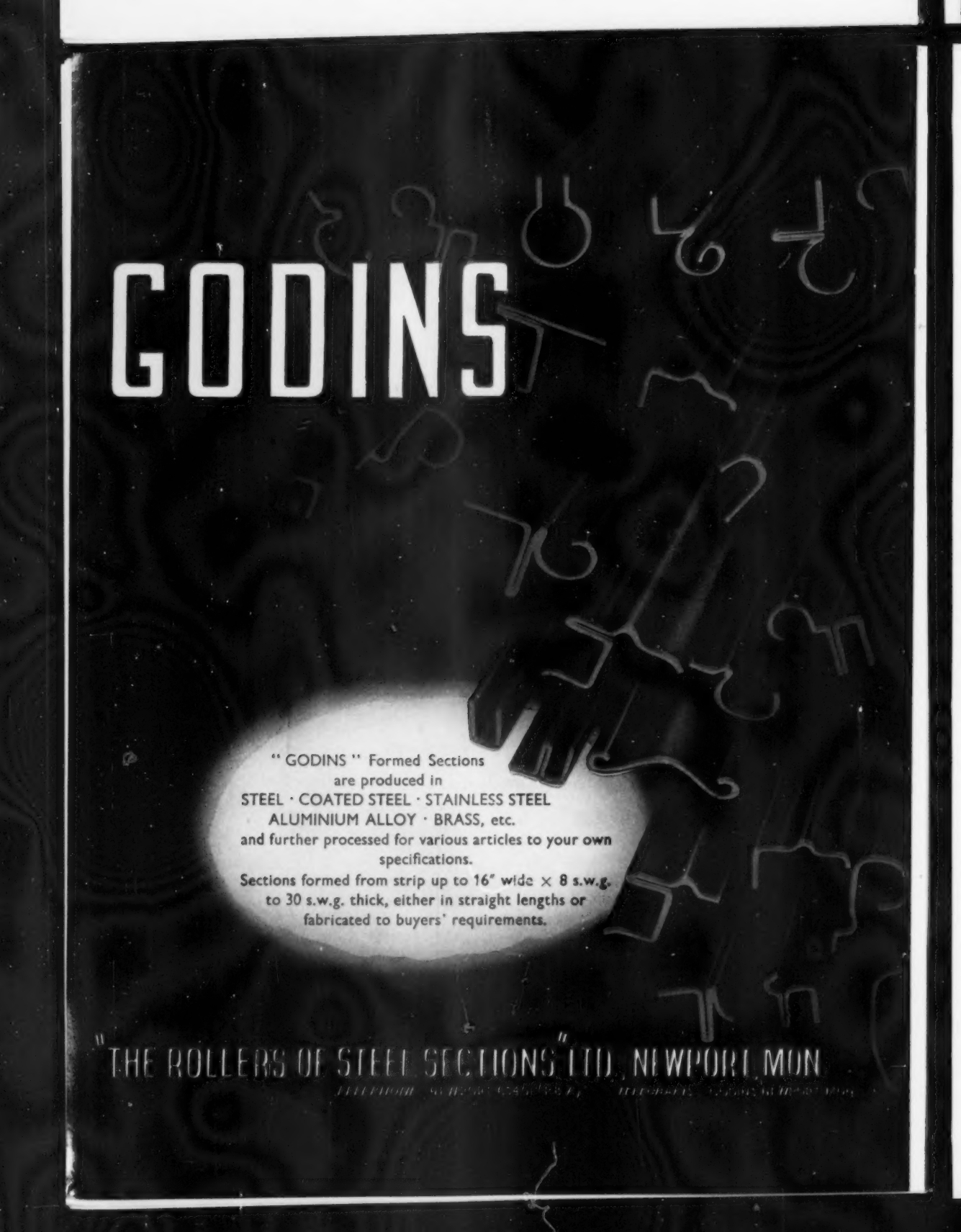

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The new 50 lb. cylinder will be specially painted, labelled and handled to avoid confusion with other types.

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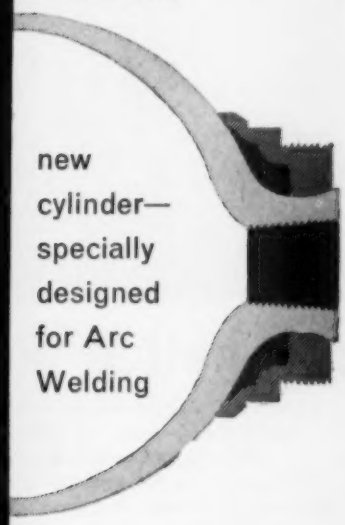

new cylinder—specially designed for Arc Welding

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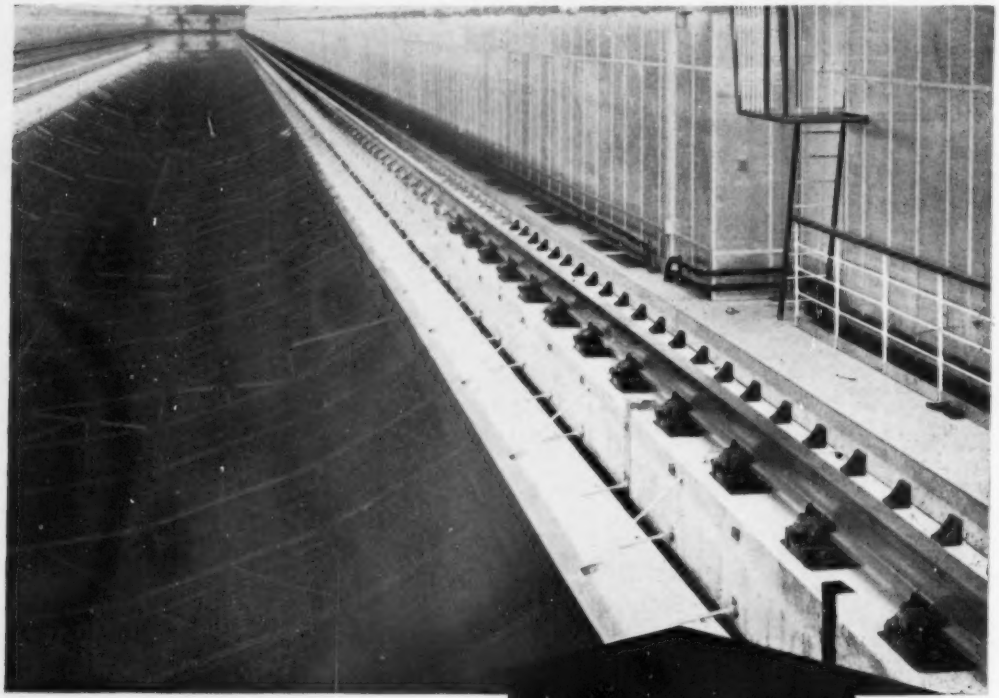

half a mile of CELLOBOND polyester/glass

HALF A MILE of Cellobond polyester/glass panels —360 of them—damp down the waves in the Ship Hydrodynamics Laboratory Testing Tank at Feltham built by the Ministry of Works. They are used to cut the time taken between ship model test runs. The choice of Cellobond resin bonded glass fibre proves yet again the strength, durability, the resistance to rust and corrosion of this material. More and more Cellobond polyester/glass is being used—because of its structural stability and the design freedom it gives. It is ideal for car and commercial vehicle bodies, chemical containers and ducting, equipment covers and for innumerable applications where dependability is all-important. For full information about Cellobond polyester resin please write for Booklet No. 106

Cellobond is a reg'd trade mark
Wave damping panels for the S.H.L. Testing Tank were made by Miles Structural Plastics Ltd., Shoreham Airport, using Cellobond polyester resins.

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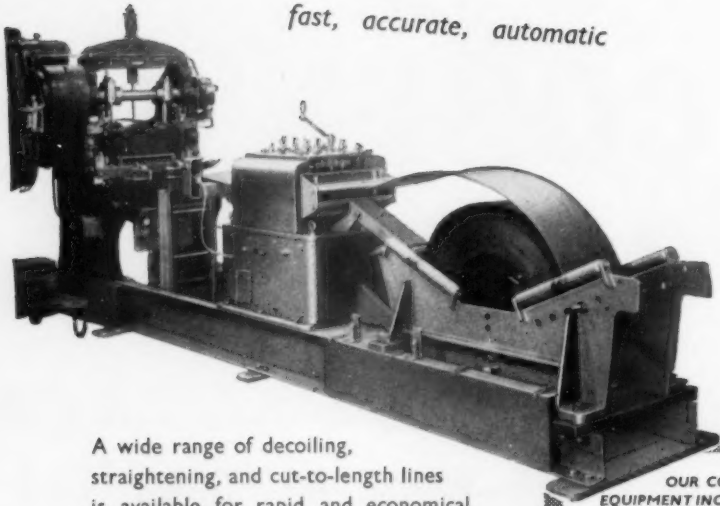

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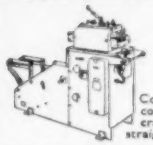
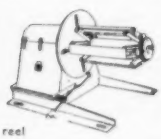
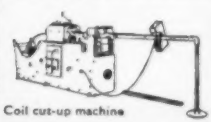


Combined coil cradle and straightener



Coil reel



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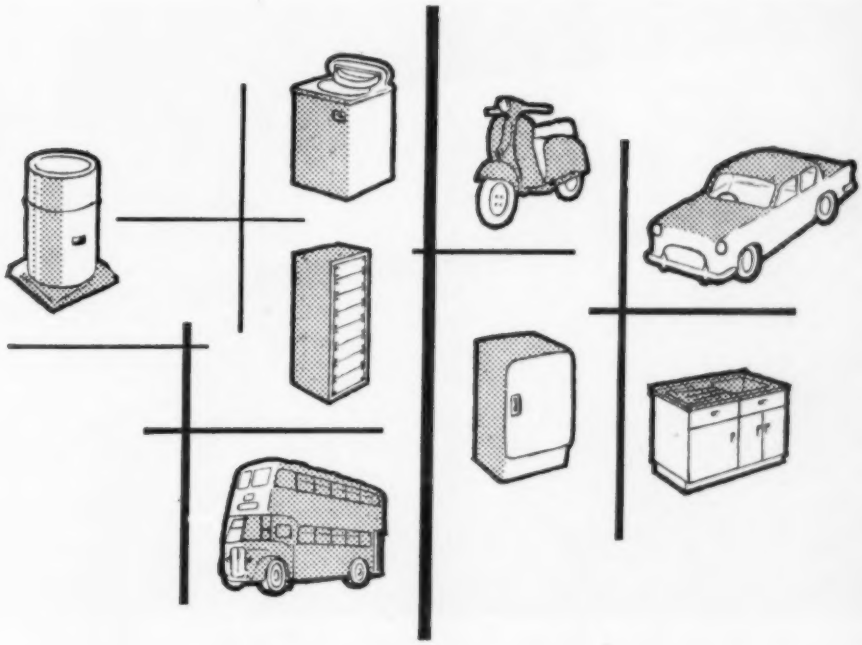

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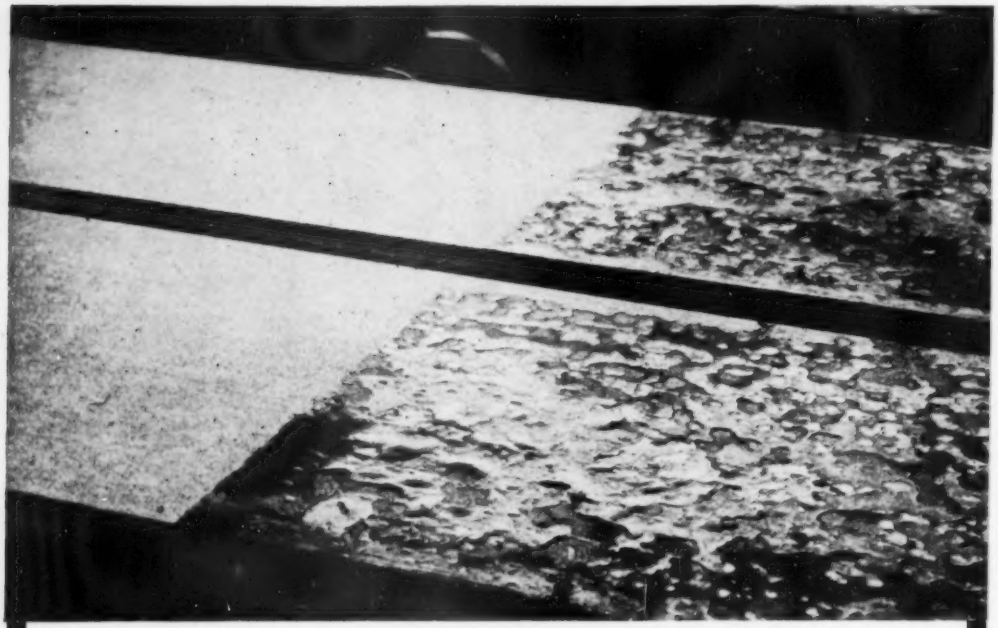

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BK 24	1200	140	—
BK 24A	1200	140	Integral
BK 24B	1200	140	Clamp on
BK 34	2400	355	—
BK 34A	2400	355	Integral
BK 34B	2400	355	Clamp on
BK 42	600	56	—
BK 42A	600	56	Integral
BK 42B	600	56	Clamp on
BK 66	300	22·4	—

* Ratings are for welder control service with two valves in inverse parallel at any voltage from 250-600v. r.m.s.

Rectifier types

Type	Maximum peak voltage (Kilo volts)	Maximum average current at peak voltage (Amps.)
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BK 46	2·1	150
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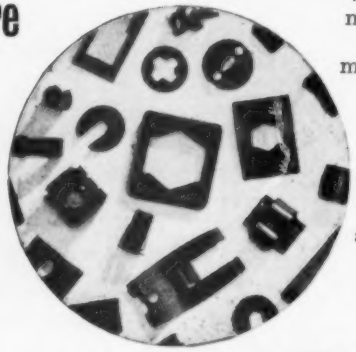

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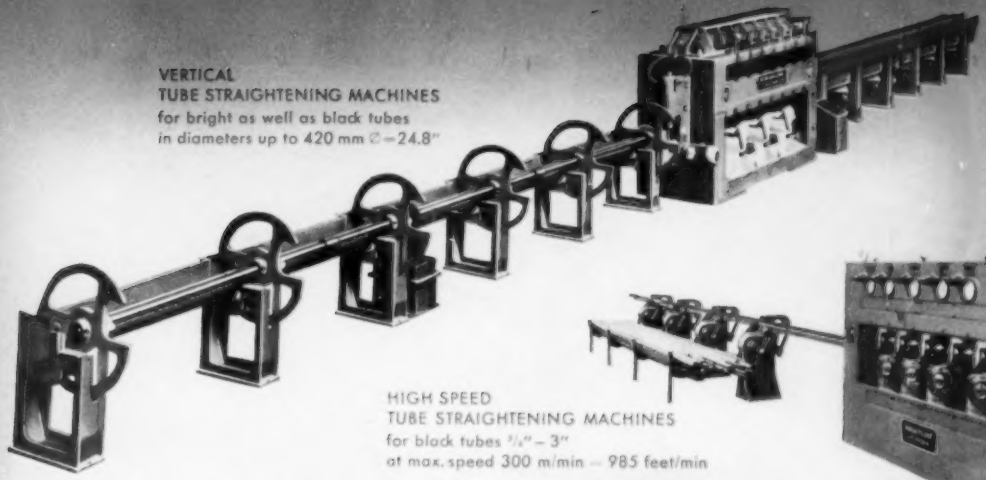

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for bright as well as black tubes
in diameters up to 420 mm ∅ = 24.8"

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for black tubes ¾" – 3"
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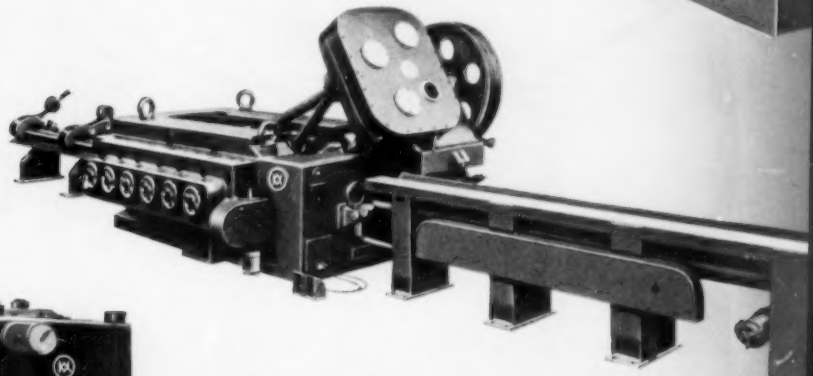

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STRAIGHTENING
MACHINES

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BAR STRAIGHTENING
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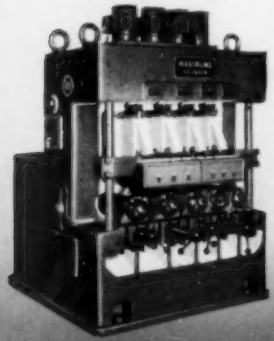
FOR BARS AND PROFILES



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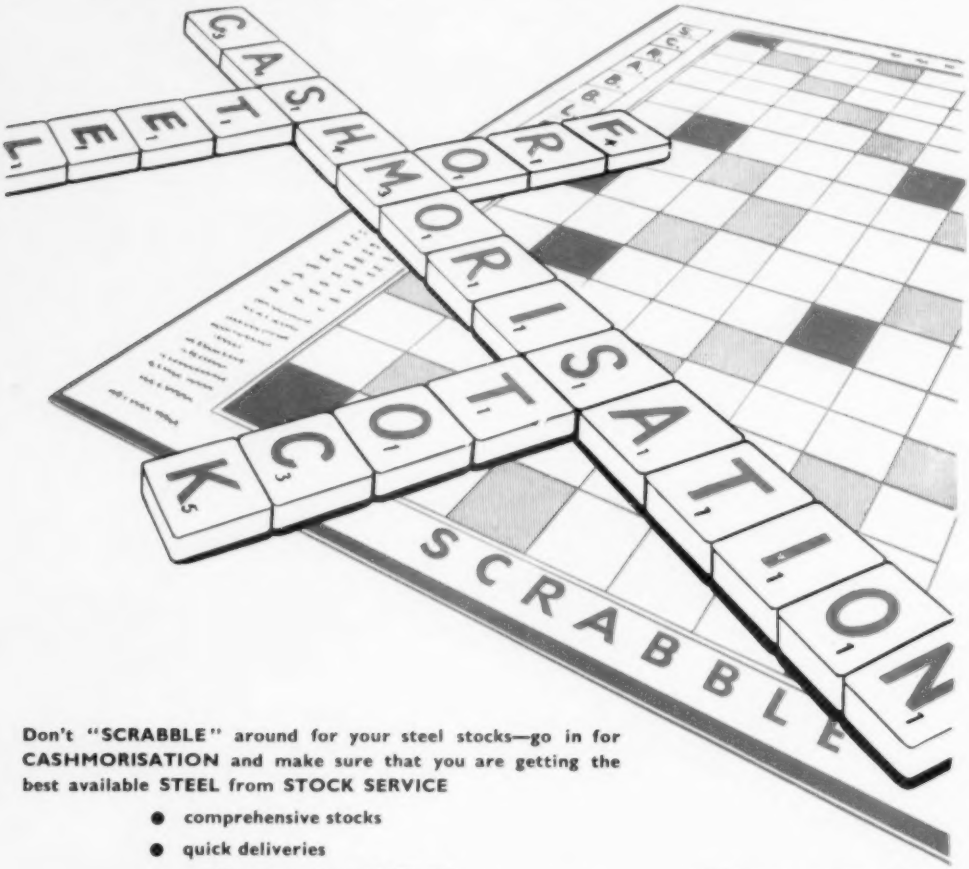

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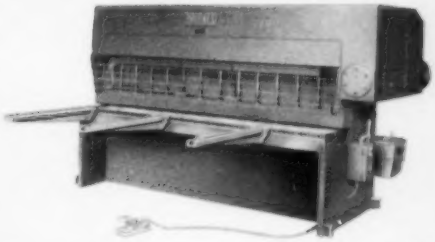

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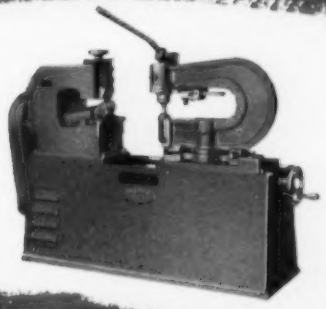

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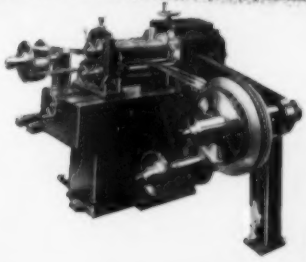

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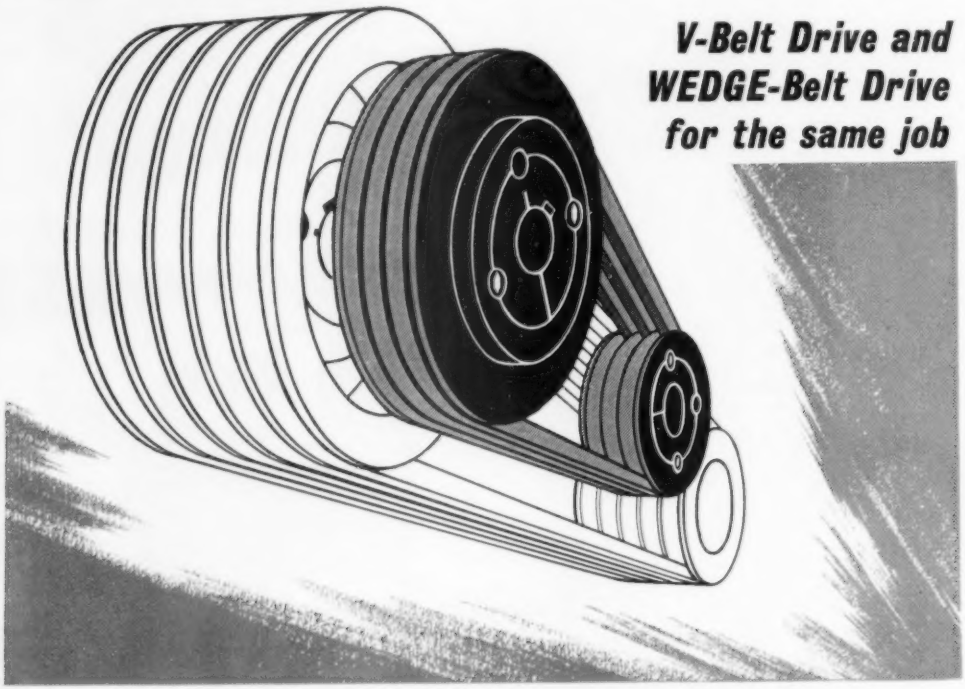

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Slimmer, Lighter, Shorter, Cheaper

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	Wedge-Belt	3·15	5·60	$1\frac{1}{2}$	3 Alpha 280	7·1	£5 · 3 · 8	10·6
	SAVING	**16%**	**12%**	**54%**	—	**5%**	**19%**	**36%**
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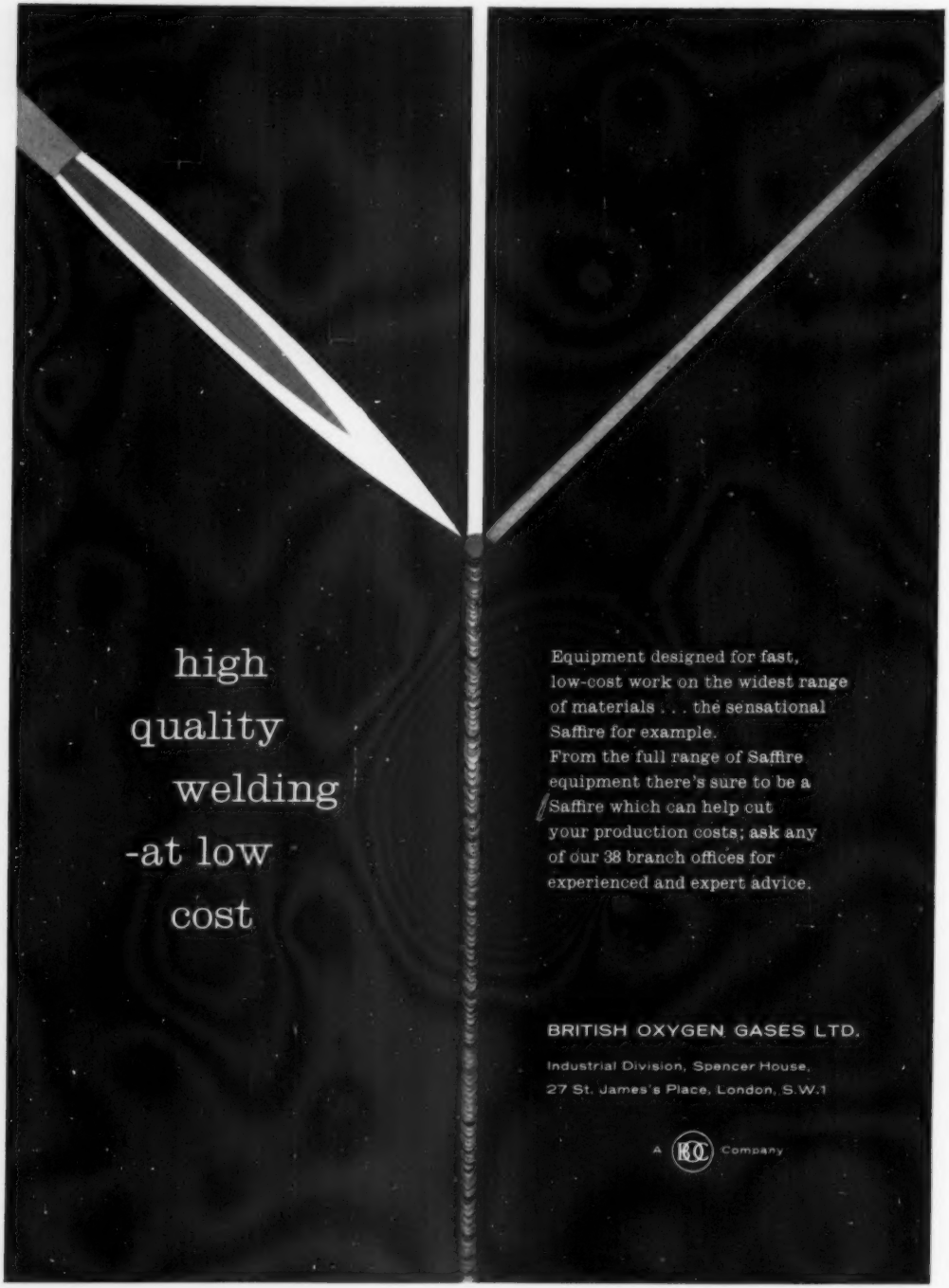
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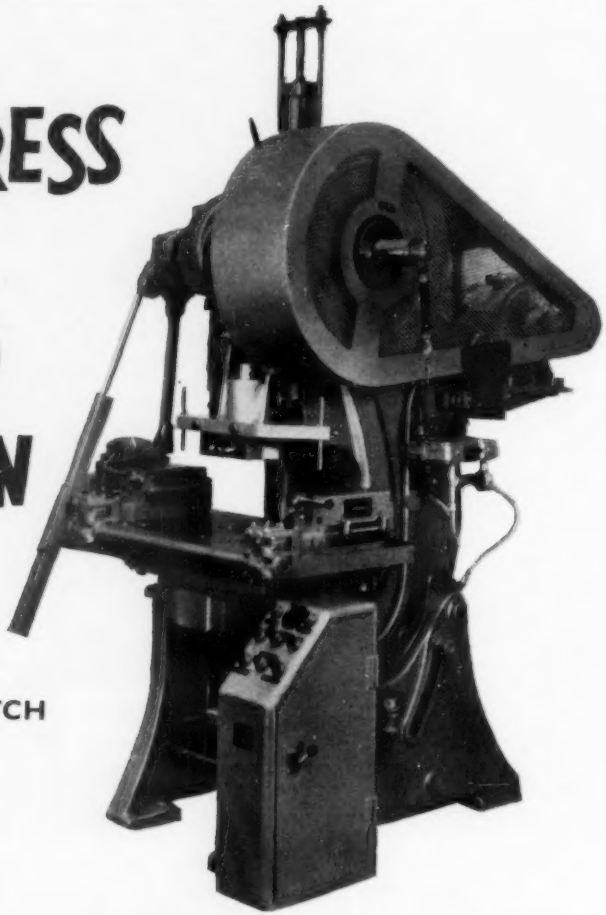
WPS 103

A POWER PRESS for your INCREASED PRODUCTION



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AIR FRICTION CLUTCH

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An entirely fresh design approach to the problem of providing a reliable high speed press with the simplest possible control arrangement.
The A. 25F is a logical development from the earlier CP. 25 range of presses and is the outcome of considerable experience. The clutch, variable speed drive and clutch system are all well proved proprietary items chosen by HUMPHRIS engineers as being the most reliable accessories available today.

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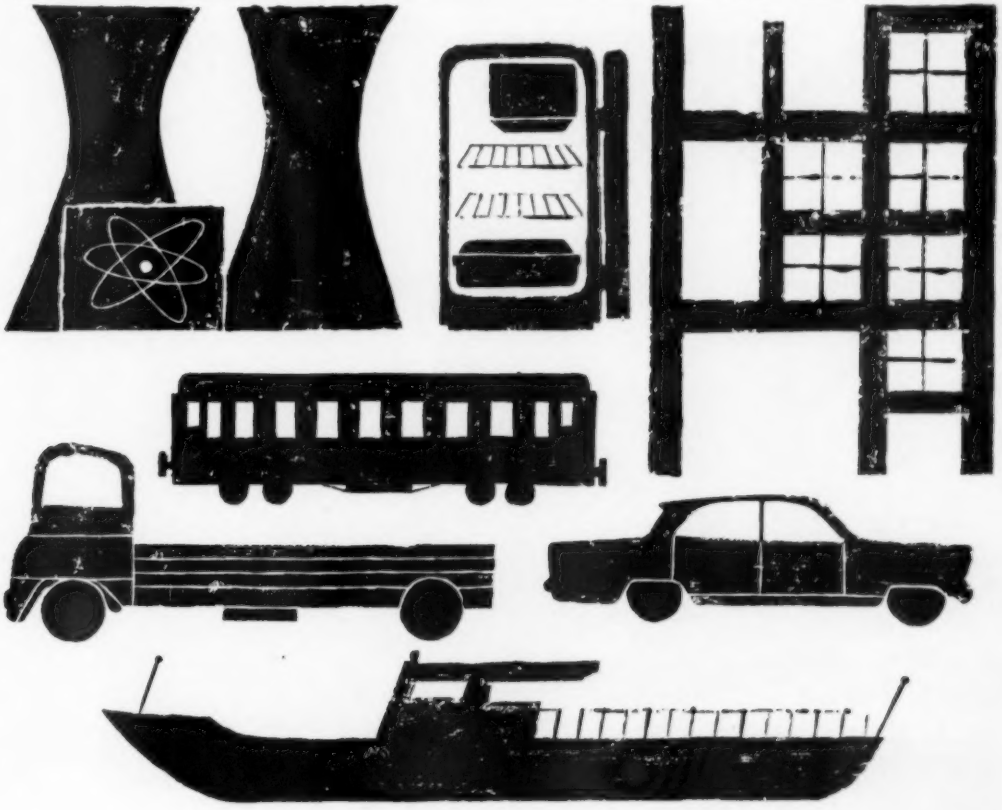

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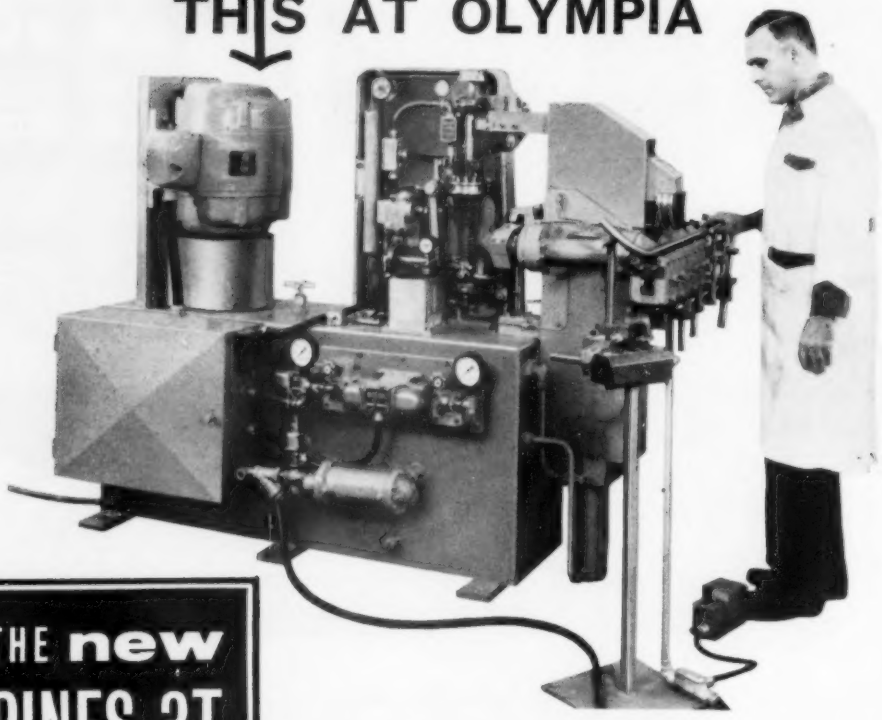

THE new PINES 3T PRESS BENDER

In addition to the model 3T, Pines also build a complete line of Press Benders for tubes up to 2" o.d. Particulars of any machine on request.

CUTS BENDING COSTS as much as 50%

Progressive bends to varied angles in multiple planes are now possible two to three times faster than conventional methods with the new Pines 3T Bending Press. Up to nine different bend angles can be produced in a single set up in sizes up to 1" O.D.

The Pines 3T Press meets the high production demands of a wide range of modern manufacturing industries, in particular the automotive, office equipment and appliance industries.

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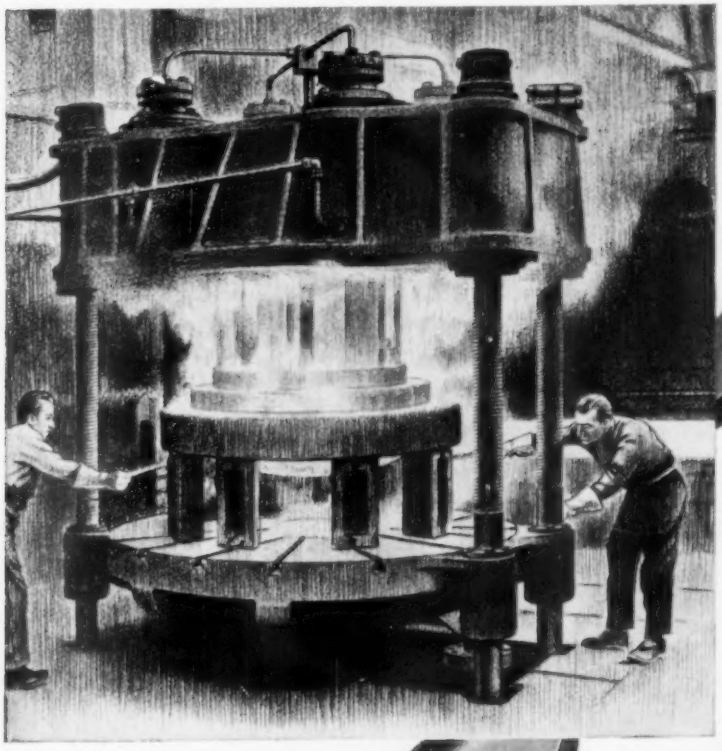

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Fabrication of pressure vessels may be greatly facilitated by drawing upon Harvey resources for the production of die-pressed Dished and Flanged Ends.

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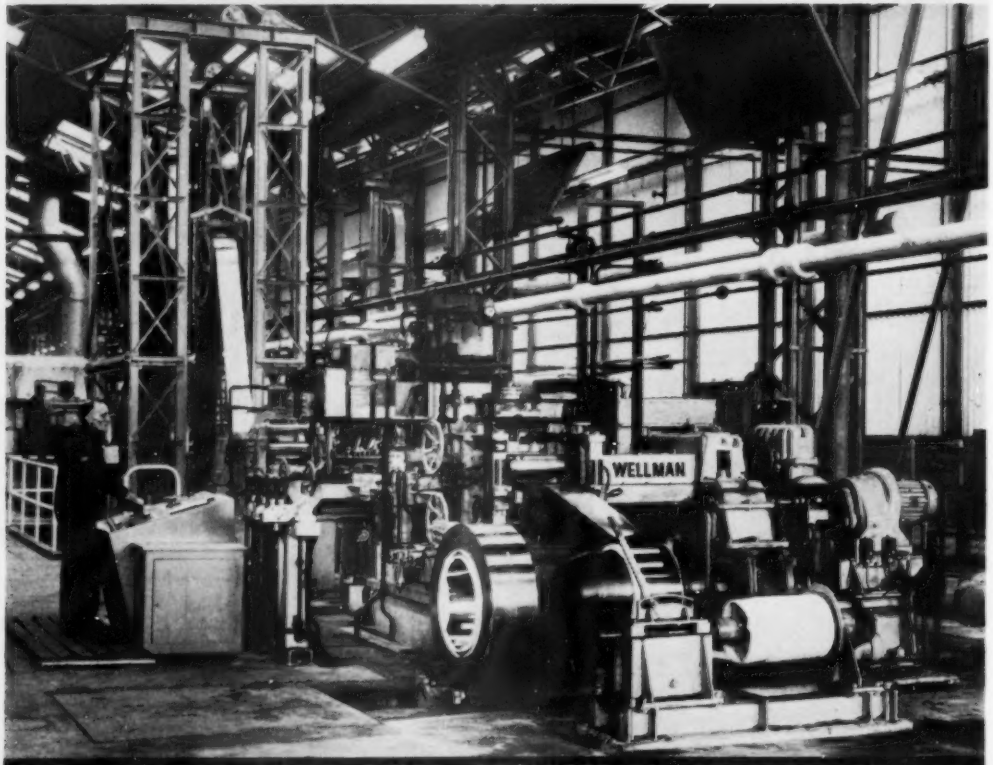

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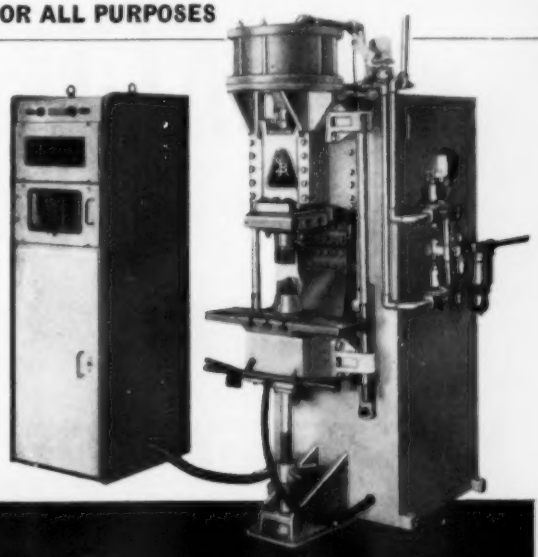
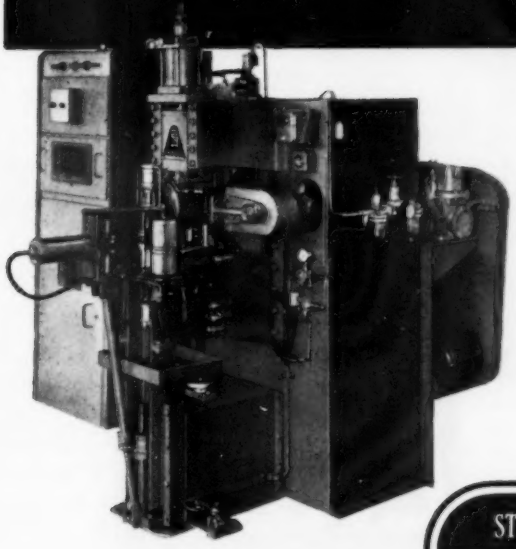
Good delivery and the services of our qualified technical staff are available to advise on your welding problem.

On right: 150 K.V.A. Vertical Sliding Head, Air Operated Electric Hot Closing Machine. Full Electronic Control with Phase Shift Current Regulation and Timed Double Pressure.



RESISTANCE WELDERS



Manufacturers of all types of Welding Machines including foot and air operated pivot type Spot Welders. Vertical Sliding Head Spot and Projection Welders with full electronic control. Seam Welders. Flash Butt Welders. Rivet Heaters. Auto Wire Butt Welders. Vertical Sliding Head electric resistance Hot Closing Machines with full electronic control of pressure and current.

On left: 80 K.V.A. Air Operated Electric Circumferential Seam Welder with Phase Shift Current Regulation and Electronic Control.

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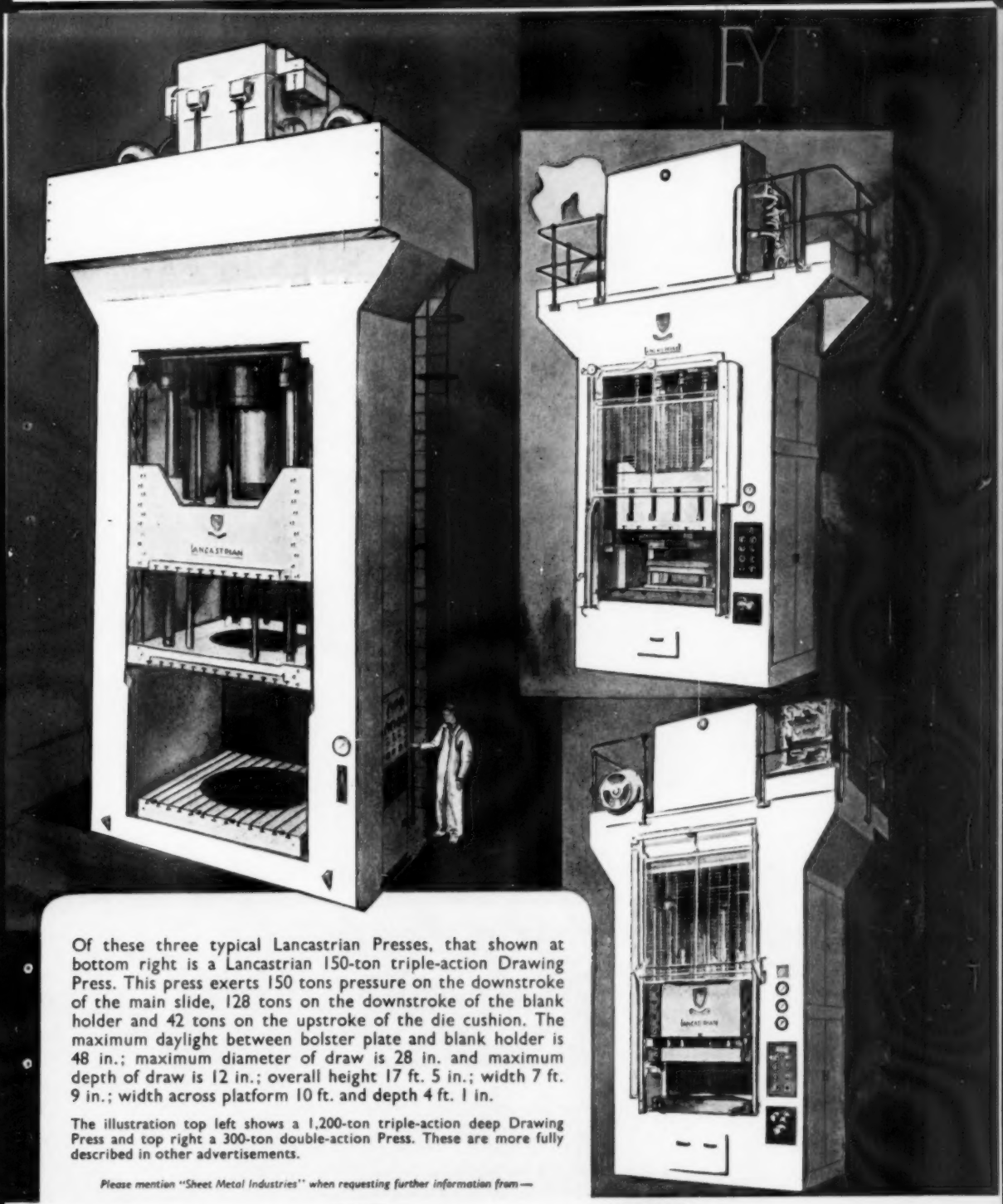
WPS 331



Of these three typical Lancastrian Presses, that shown at bottom right is a Lancastrian 150-ton triple-action Drawing Press. This press exerts 150 tons pressure on the downstroke of the main slide, 128 tons on the downstroke of the blank holder and 42 tons on the upstroke of the die cushion. The maximum daylight between bolster plate and blank holder is 48 in.; maximum diameter of draw is 28 in. and maximum depth of draw is 12 in.; overall height 17 ft. 5 in.; width 7 ft. 9 in.; width across platform 10 ft. and depth 4 ft. 1 in.

The illustration top left shows a 1,200-ton triple-action deep Drawing Press and top right a 300-ton double-action Press. These are more fully described in other advertisements.

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The slideways have a two degree forward slope so that on the downward stroke the slide is moving downwards and backwards ensuring the sheared edge being at right angles to the blade and a cleaner edge as a result.

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Series 25, is available in the following capacities (mild steel): 6 ft. × ¼ in; 8 ft. × ¼ in; 10 ft × ¼ in.; 12 ft. × ¼ in.

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Wolves have come a long way from their modest origin in 1877 as St. Luke's Church School Team. Original members of the F.A., which they joined in 1888, they pursued their path to fame, undaunted by a temporary descent into the Third Division North in 1923; even this lapse had its consolations, making Wolves the only Club to have been champions of three Divisions of the Football League.
To-day, Wolves' future is as bright as their celebrated strip. The name and fame of Wolverhampton Wanderers have spread to every part of the world where football is played and appreciated.

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Bright Flattened Mild Steel Wire, with Round and Square Edges.

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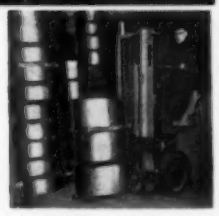

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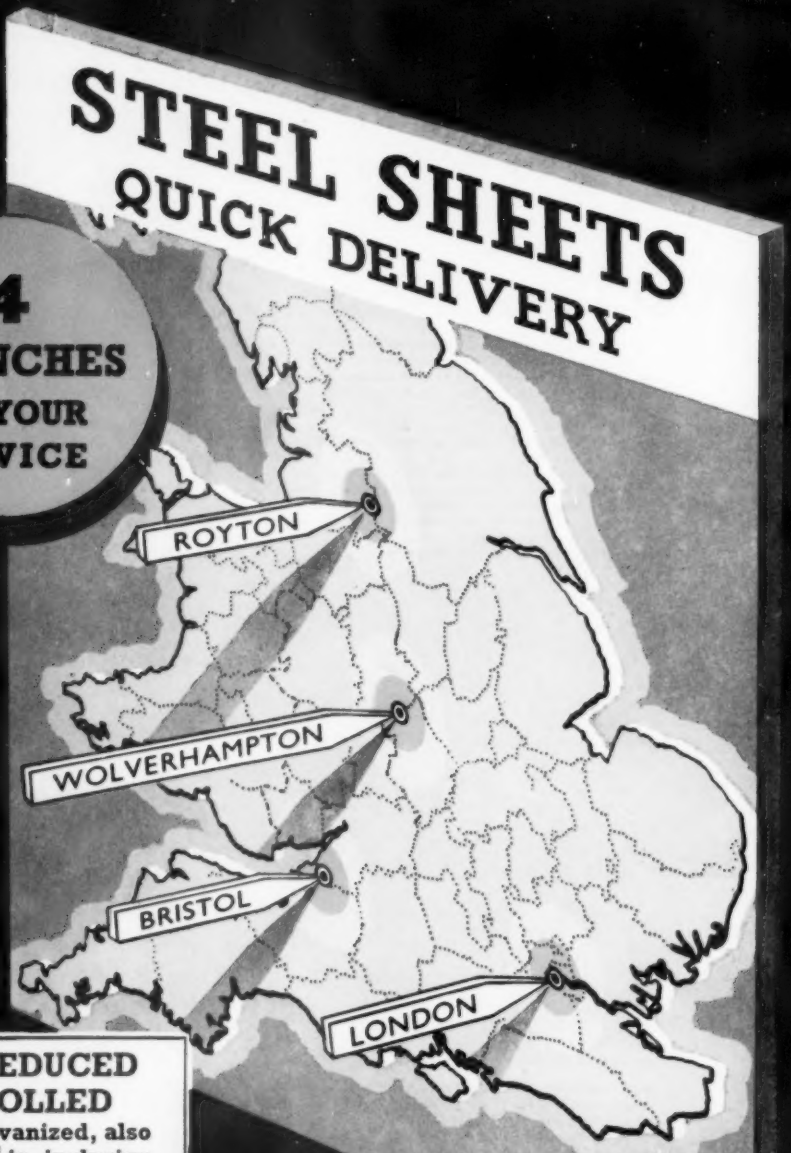

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SEPTEMBER 1960
No. 401 Vol. 37

Sheet Metal Industries

Incorporating PRESS TOOL ENGINEERING

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THE QUEST FOR SUPERMAN

ONE evening last June a number of eminent representatives of the engineering industry and of educational institutions met by invitation at the Institute of Welding to take part in a select conference convened to discuss Advanced Education in Welding.

The deficiencies in the present situation were discussed after four introductory addresses had drawn attention in turn to the rapid rate of technical and scientific advance in welding processes, to the effort made in providing facilities for higher welding education in other countries as compared with what is done in the U.K., to what should be the ultimate standard and scope at which a properly-designed course of study should aim, and finally to what action the Ministry of Education was proposing to take to make suitable provision for education in welding at an advanced level.

On some of the issues raised there was no disputation as they involved matters of generally recognized fact. But, in the attempt to define the real needs of industry in this regard, and to assess the amount of support that could be looked for for such advanced educational schemes as might be brought into being, large areas were revealed in which substantially opposing views were held.

The initial proposals put forward for the desirable content and scope of a course of study for welding technologists were pitched in such a key as to envisage the production of an individual with a wealth of engineering and metallurgical knowledge of such magnitude as to lead to his being referred to in subsequent discussion as "Superman."

Quite obviously the availability of a technological Superman would be a considerable asset in any organization, but doubt can reasonably be expressed as to whether the supply could ever be adequate to meet the demand. Recognizing the difficulties of obtaining the services of a Superman, present-day industry tends to compromise in his absence by making use of a team, each specialist member of which contributes his quota to the discussion of the project under review. This can be a satisfactory arrangement provided that due weight is given to the informed opinion of each member of the team, but there seemed to be some grounds for the complaint made at the recent Conference that enlightened views put forward by welding enthusiasts, which call for modifications in traditional designs or materials usage are frequently met with suspicion, or even, on occasion, derision.

Sooner or later it must be recognized that welding is a specialized technology whose rapid development is opening up broad new vistas in engineering design and construction. To explore this new territory, properly trained personnel will be needed in far greater numbers than are available at present, and rapid action is needed if British industry is not to be outdistanced by its industrial competitors. The quest for Superman may well prove to be a wild-goose chase; the introduction of adequate instruction in welding into our engineering educational syllabuses can only increase the supply of golden eggs.

The Study of

STRAIN-AGEING IN RIMMING STEEL USING THE SWIFT CUPPING PRESS*

and the Influence of Punch Shape on the Results

By D. K. O. ULLMANN† and V. M. THOMAS†

SUMMARY

THIS paper describes the experiments carried out to determine whether the Swift cupping test can follow the progress of strain-ageing in cold-reduced, annealed, skin-passed rimming steel. It was thought that a modification in the punch shape to increase stretch-forming might result in a more marked discrimination between aged and non-aged material and the investigation was therefore carried out using six different punches, namely the orthodox flat-nosed and hemispherical punches and four ellipsoidal punches whose ratios of minor to major radii were 1 : 1⅛, 1 : 1¼, 1 : 1½ *and* 1 : 2.

Cupping-test results were obtained with each punch on material in the freshly skin-passed condition and after ageing at 100° C. *for periods up to* 4 *hours. Tensile-test results, hardness values, and Olsen figures were also obtained for the material before and after ageing.*

The Swift cupping-test results show that the test, carried out under the conditions described does not discriminate sufficiently between the change in mechanical properties obtained after different periods of ageing to enable it to be used as a tool for studying the progress of strain-ageing.

Introduction

COLD-REDUCED, annealed, skin-passed rimming steel is subject to a phenomenon known as strain-ageing. The effect of this upon the mechanical properties of the steel is reflected in an increase in the lower yield point, the yield-point elongation, and the hardness, and a reduction in the Olsen and Erichsen figures. A slight increase in the ultimate tensile strength may also be found, and the elongation, measured on the fractured tensile pieces may be reduced, although this does not occur in every case. In practice a lift of sheets which has aged appreciably will be difficult to press satisfactorily; generally the material splits in the press.

The work described in this paper has been carried out to ascertain whether the Swift cupping test can be used to follow the progress of strain-ageing, and whether the results are influenced by the shape of the punch. The use of punches of different shapes permits a variation in the amount of stretch-forming which takes place during the drawing of the Swift cup.

Description of the Press and Tools

The press used for this work is one specially constructed by Rubery, Owen and Co. Ltd. for carrying out the Swift cupping test and is similar to that described by Coupland(1). The punch is moved by a hydraulically-operated ram and its speed can be regulated. The blankholding load is applied pneumatically.

The hemispherical and flat-nosed punches used were those originally supplied with the machine. Both punches have a diameter of 2 in.; the edge radius of the flat-nosed punch is 0.198 in. These punches and also the die are made of tool steel and have a Vickers hardness number greater than 700. The diameter of the die is 2.134 in. and its edge radius is 0.48 in.

For the experimental work on different punch shapes it was decided to construct ellipsoidal-nosed punches. The semi-ellipse forming the nose can be blended smoothly into the parallel part of the punch, the diameter of which forms the minor axis of the semi ellipse. Four punches were made with the following ratios of minor to major axis :— 1 : 1⅛, 1 : 1¼, 1 : 1½ and 1 : 2. Since this work was considered experimental in the sense of finding an optimum punch shape and these punches were not intended for service for any length of time, it

TABLE I—*Hardness Values of Tools*

Tool	Average Vickers hardness number
Die	738
Flat-nosed punch	757
Hemispherical punch	770
1 : 1⅛ ellipsoidal punch	107
1 : 1¼ ellipsoidal punch	132
1 : 1½ ellipsoidal punch	161
1 : 2 ellipsoidal punch	201

* A paper presented to a meeting of the International Deep Drawing Research Group, Paris, May, 1960.

† Richard Thomas & Baldwins Ltd., Central Research Laboratories.

was not considered necessary to expend the time in preparing punches of the same hardness as the standard punches. The hardness figures for all the tools are given in Table I.

Experimental Procedure

Twenty consecutive sheets 41 in. wide and 20 s.w.g., were taken from a lift which had been skin-passed on a 4-high temper mill. The initial length of the sheets was 69 $\frac{11}{16}$ in. and after skin-passing all 20 sheets fell within the range of 70 $\frac{7}{16}$ in. and 70$\frac{1}{2}$ in. Thus the elongation given to these sheets is within the limits of 1.08 per cent to 1.17 per cent, being nominally 1.1 per cent.

A 5$\frac{1}{2}$-in. wide strip was sheared off each edge of the sheets and discarded. This was done to ensure that none of the material tested came from the rim only. Within 30 hours of skin-passing all the sheets had been cut into smaller strips and were stored in two refrigerators at a temperature of $-20°$ C. The material was withdrawn from these refrigerators only when required for testing.

The blanks for the Swift cupping test were prepared by cutting the sheets into 5-in. squares, trimming off the corners, and machining the resulting octagons individually on a lathe to the required diameters. All machining flash was removed by hand filing. Excess oil and swarf were wiped off and the blanks were aged for the required time by immersion in boiling water. At the end of the ageing period the blanks were immediately cooled in cold water, dried and degreased by swabbing with carbon tetrachloride. Thickness measurements were taken on each blank before testing. Before each set of blanks was tested the tools and the blankholder were cleaned, degreased and then lightly oiled with the drawing lubricant. The speed of the punch stroke was timed at frequent intervals to ensure that all tests were carried out at the same punch speed of 4 ft. per min. Immediately before testing the blanks were dipped into the drawing lubricant and then passed twice through a pair of lightly-loaded rubber-covered squeegee rolls. This procedure differs slightly from that recommended by Kemmis[2] but has the advantage of providing an even film of oil and is much less messy.

The drawing lubricant was Esso oil TSD.996 supplied by the manufacturers as conforming to the specification set out by Kemmis[2].

Before starting the experiment a number of blanks of 4.40 in. diameter were drawn to determine the blankholder pressure required. It was found that 30 lb. per sq. in. pressure would just suppress wrinkling and it was decided to use 50 lb. per sq. in. pressure throughout the whole series of tests except when the effect of blankholder pressure was investigated.

Single blanks were drawn initially to determine approximately the limiting diameter. Five confirmatory blanks for the limiting diameter and for each interval of diameter above and below the limiting diameter were drawn. This was continued above and below the limiting diameter until for a given diameter the results generally showed 100 per cent draw and 100 per cent fail.

The tensile-test pieces were machined to conform to the dimensions given for test-piece Al in B.S.18 : 1956, and were subjected to the same ageing as were the cupping-test blanks. The tensile tests were pulled on a hydraulic tensile-testing machine at a constant cross-head speed of 1 in. per min. calibrated without load.

Olsen stretch-forming tests and Rockwell hardness tests were also carried out on samples representing all the ageing times.

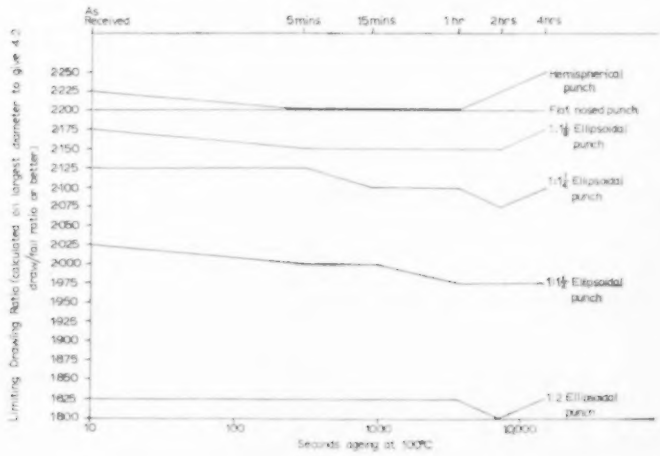


Fig. 1.—Variation of Limiting Drawing Ratio with ageing time

Experimental Results

Swift Cupping Test

Complete results for each tool are shown in Tables II to VII. The limiting blank diameter has been taken throughout this paper to be the greatest diameter at which a minimum of four blanks out of six can successfully be drawn and the limiting drawing ratio has been calculated from this diameter. The relationship between limiting drawing ratio and ageing time is shown graphically in Fig. 1. Since the 1 : 1½ ellipsoidal punch showed the most pronounced trend in following the strain ageing, it was decided to see whether by altering the blankholder pressure this trend could be

TABLE II—*Results of Cupping Tests Using Hemispherical Punch*

Ageing time at 100° C.	Blank diameter (inches)									
	4.35		4.40		4.45		4.50		4.55	
	Drew	Failed	Drew	Failed	Drew	Failed	Drew	Failed	Drew	Failed
As received	—	—	6	0	4	2	0	6	—	—
5 minutes	6	0	4	2	0	6	—	—	—	—
15 minutes	6	0	4	2	3	3	0	6	—	—
1 hour	—	—	6	0	0	6	—	—	—	—
2 hours	6	0	5	1	4	2	2	4	0	6
4 hours	—	—	—	—	6	0	5	1	0	6

TABLE III—*Results of Cupping Tests Using Flat-nosed Punch*

Ageing time at 100° C.	Blank diameter (inches)							
	4.35		4.40		4.45		4.50	
	Drew	Failed	Drew	Failed	Drew	Failed	Drew	Failed
As received	—	—	6	0	3	3	0	6
5 minutes	6	0	5	1	1	5	—	—
15 minutes	—	—	5	1	0	6	—	—
1 hour	—	—	5	1	3	3	0	6
2 hours	6	0	5	1	0	6	—	—
4 hours	—	—	6	0	1	5	0	6

TABLE IV—*Results of Cupping Tests Using* 1 : 1½ *Ellipsoidal Punch*

Ageing time at 100° C.	Blank diameter (inches)									
	4.25		4.30		4.35		4.40		4.45	
	Drew	Failed	Drew	Failed	Drew	Failed	Drew	Failed	Drew	Failed
As received	—	—	6	0	5	1	2	4	0	6
5 minutes	—	—	6	0	3	3	1	5	—	—
15 minutes	—	—	6	0	2	4	2	4	0	6
1 hour	—	—	6	0	2	4	0	6	—	—
2 hours	6	0	5	1	0	6	—	—	—	—
4 hours	—	—	6	0	5	1	1	5	0	6

TABLE V—*Results of Cupping Tests Using* 1 : 1¼ *Ellipsoidal Punch*

Ageing time at 100° C.	Blank diameter (inches)									
	4.15		4.20		4.25		4.30		4.35	
	Drew	Failed	Drew	Failed	Drew	Failed	Drew	Failed	Drew	Failed
As received	—	—	—	—	6	0	2	4	1	5
5 minutes	—	—	6	0	4	2	1	5	0	6
15 minutes	—	—	6	0	1	5	0	6	—	—
1 hour	—	—	6	0	2	4	0	6	—	—
2 hours	6	0	3	3	0	6	—	—	—	—
4 hours	6	0	4	2	0	6	—	—	—	—

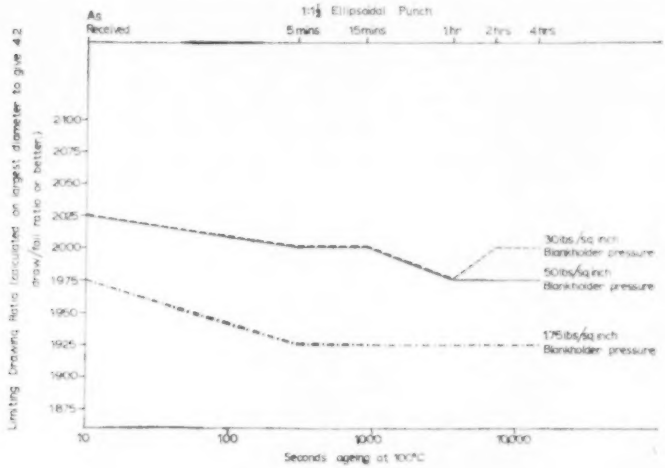


Fig. 2.—Effect of varying blankholder loads upon Limiting Drawing Ratio

accentuated. Fig. 2 and Table VIII show the effect of varying the blankholder pressure from 30 lb. per sq. in. to 175 lb. per sq. in. when drawing aged blanks with the 1 : 1½ ellipsoidal punch.

The blank thicknesses varied from 0.036 in. to 0.0395 in. but although the results have not been examined statistically there appeared to be no tendency for this gauge variation to influence the results of the cup-drawing test.

Mechanical Tests

The results of the tensile tests, elongation, hardness and Olsen tests are given in Table IX and are shown graphically in Figs. 3 to 5. Four longitudinal and four transverse tensile pieces were tested after each ageing period and the results shown in the table are the averages of the individual results. The Olsen and Rockwell results are the averages of six individual tests.

Chemical Analysis

The chemical analysis of the steel used for this investigation is given in Table X.

TABLE VI—*Results of Cupping Tests Using* 1 : 1½ *Ellipsoidal Punch*

Ageing time at 100° C.	Blank diameter (inches)							
	3.95		4.00		4.05		4.10	
	Drew	Failed	Drew	Failed	Drew	Failed	Drew	Failed
As received	—	—	6	0	5	1	0	6
5 minutes	6	0	4	2	2	4	1	5
15 minutes	—	—	6	0	0	6	—	—
1 hour	6	0	1	5	0	6	—	—
2 hours	6	0	3	3	2	4	0	6
4 hours	6	0	3	3	2	4	0	6

TABLE VII—*Results of Cupping Tests Using* 1 : 2 *Ellipsoidal Punch*

Ageing time at 100° C.	Blank diameter (inches)							
	3.60		3.65		3.70		3.75	
	Drew	Failed	Drew	Failed	Drew	Failed	Drew	Failed
As received	—	—	6	0	1	5	0	6
5 minutes	6	0	6	0	1	5	—	—
15 minutes	6	0	5	1	0	6	—	—
1 hour	6	0	5	1	0	6	—	—
2 hours	6	0	3	3	0	6	—	—
4 hours	6	0	4	2	0	6	—	—

TABLE VIII—*Results of Cupping Tests Using 1 : 1½ Ellipsoidal Punch Using Differing Blankholder Pressures*

Blankholder pressure	Ageing time at 100° C.	Blank diameter (inches)													
		3.80		3.85		3.90		3.95		4.00		4.05		4.10	
		D	F	D	F	D	F	D	F	D	F	D	F	D	F
30 lb. per sq. in.	As received	—	—	—	—	—	—	—	—	6	0	5	1	1	5
	5 min.	—	—	—	—	—	—	—	—	6	0	0	6	—	—
	15 min.	—	—	—	—	—	—	—	—	6	0	2	4	0	6
	1 hour	—	—	—	—	—	—	6	0	3	3	0	6	—	—
	2 hours	—	—	—	—	—	—	—	—	6	0	1	5	0	6
	4 hours	—	—	—	—	—	—	6	0	4	2	0	6	—	—
50 lb. per sq. in.	As received	—	—	—	—	—	—	—	—	6	0	5	1	0	6
	5 min.	—	—	—	—	—	—	6	0	4	2	2	4	1	5
	15 min.	—	—	—	—	—	—	—	—	6	0	0	6	—	—
	1 hour	—	—	—	—	—	—	6	0	1	5	0	6	—	—
	2 hours	—	—	—	—	—	—	6	0	3	3	2	4	0	6
	4 hours	—	—	—	—	—	—	6	0	3	3	2	4	0	6
175 lb. per sq. in.	As received	—	—	—	—	—	—	6	0	0	6	—	—	—	—
	5 min.	—	—	6	0	1	5	0	6	—	—	—	—	—	—
	15 min.	6	0	5	1	0	6	—	—	—	—	—	—	—	—
	1 hour	6	0	5	1	2	4	0	6	—	—	—	—	—	—
	2 hours	5	1	5	1	1	5	1	5	—	—	—	—	—	—
	4 hours	6	0	5	1	2	4	1	5	—	—	—	—	—	—

TABLE IX—*Results of Mechanical Tests*

Ageing time at 100° C.	Yield point tons per sq. in.		Ultimate tensile strength tons per sq. in.		Yield point elongation per cent on 8 in.		Elongation per cent on 8 in.		Elongation per cent on 2 in.		Rockwell "B" scale	Olsen (in.)
	L	T	L	T	L	T	L	T	L	T		
As received ..	13.1	13.5	20.7	20.9	0	0	31	29	47	44	40.5	0.412
5 min. ..	15.9	16.4	21.0	20.9	3	4	30	28	45	45	42.5	0.407
15 min. ..	16.8	17.6	21.2	21.1	4	5.5	30	28.5	45	45	43	0.402
1 hour ..	17.3	17.7	21.0	21.1	5	6	29.5	26	45	43	43	0.385
2 hours ..	17.2	18.0	21.0	21.0	5	6	31	26.5	45	42	44	0.389
4 hours ..	17.8	18.1	21.0	21.2	6	7.5	28	27	46	47	44	0.385

L = Longitudinal, T = Transverse with respect to rolling direction.

TABLE X—*Chemical Analysis of Sheet Material (per cent)*

C	S	P	Mn	Ni	Cu	Sn	N
0.038	0.017	0.011	0.29	0.028	0.040	<0.01	0.003

Discussion and Conclusions

Accepted methods of following the progress of strain-ageing are the study of the changes in the yield point, the yield point elongation, the hardness or the stretch-forming test result. Of these the study of the variation in the yield point is probably the most widely used. Fig. 3 shows clearly the progress of strain-ageing of the steel under investigation as manifested by the increase in the yield point. It might be expected therefore that any test whose results are influenced by strain-ageing will show a similar curve. An examination of the Swift cupping test results shows that none of the punches used gave a clear indication of following the strain ageing process. The results obtained with the 1 : 1½ ellipsoidal punch show a trend towards a decrease in the limiting drawing ratio with ageing time. However, this trend is not accentuated either by altering the blankholder pressure or by increasing the ellipticity of the punch. It is difficult to attach great significance to this trend since none of the results obtained with any of the punches vary over more than two increments and it may well be that the limits of discrimination are ±1 increment in the limiting drawing ratio. Certainly a number of results at various diameters have failed to give

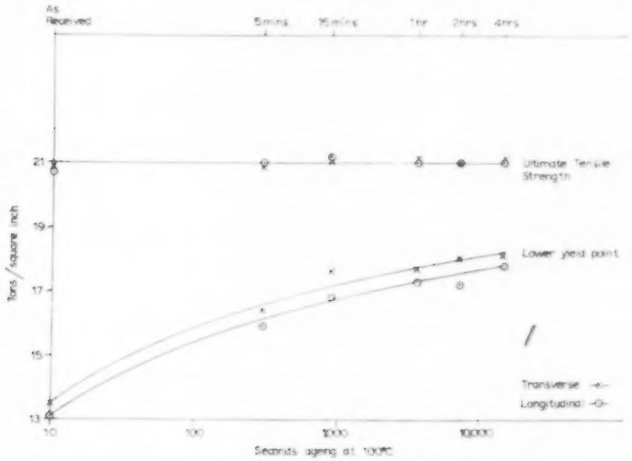
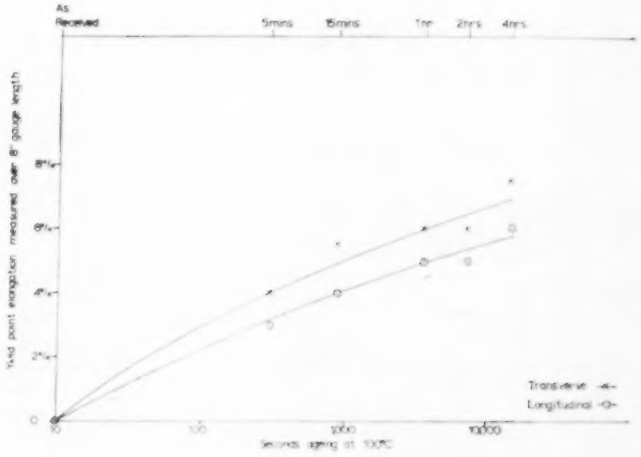


Fig. 3 (left).—Effect of ageing time upon yield point and ultimate tensile strength

Fig. 4 (below).—Effect of ageing time upon yield point elongation



an unambiguous result. Thus although it is expected that with the flat-nosed punch there should be no more than two increments between 100 per cent pass and 100 per cent fail, the ellipsoidal punches show in some cases three increments difference. Unless the difference obtained on ageing is greater than three increments over the whole ageing period it is difficult to assert that the results presented show a marked tendency to follow the progress of strain ageing.

Two other factors must also be considered. The material used for this investigation showed practically no change in ultimate tensile strength or in elongation after fracture of the tensile pieces. It is possible that a change in one or both of these factors is of greater importance in the cup drawing test than a change in the other properties investigated. It is not impossible that with longer ageing times some change in these properties takes place which might be reflected in the limiting drawing ratio. According to Hundy[3], 4 hours ageing at 100° C. is equivalent to one year at 15° C.; this latter period is much greater than the time normally allowed to elapse before a skin-passed steel is pressed and it was not, therefore, considered of practical application to continue ageing beyond 4 hours at 100° C. The results obtained are disappointing in the sense that they offer little hope of the possibility of correlating press shop results for skin-passed rimming steel with cupping press results. This is especially true for the flat-nosed punch upon which at present attention is focused as the standard punch for the test. If the cupping test is ever to be used in the mild-steel flat-rolled products field to determine the suitability or otherwise of a particular batch of steel for pressing, then one of the requirements of the test is that it should clearly distinguish between freshly skin-passed and strain-aged material. This the test fails to do when the flat-nosed punch is used and it would appear from the present work that even an increase in stretch-forming associated with the deep drawing produced by ellipsoidal punches fails

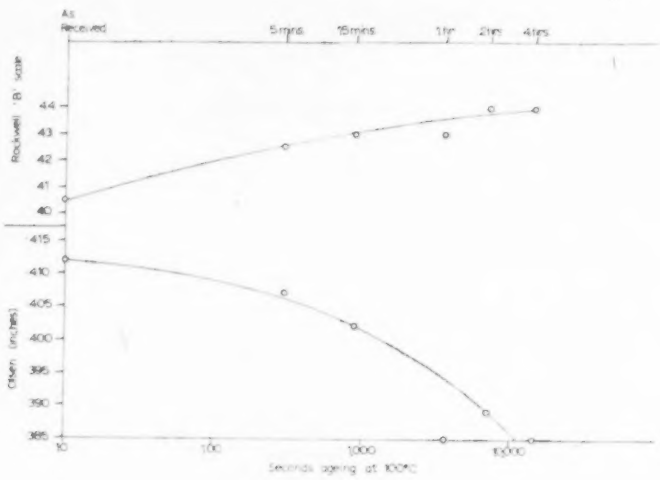


Fig. 5.—Effect of ageing time upon Rockwell and Olsen results

(*Continued in page* 690)

TABLE XI—*Cupping Test Results on Room Temperature Aged Material*

Ageing Time	Punch nose shape	Blank diameter (inches)													
		4.00		4.05		4.10		4.40		4.45		4.50		4.55	
		D	F	D	F	D	F	D	F	D	F	D	F	D	F
As received	Flat							6	0	3	3	0	6		
	Hemispherical							6	0	4	2	0	6		
	Ellipsoidal ..	6	0	5	1	0	6								
2 days	Flat							6	0	4	2	1	5		
	Hemispherical							6	0	5	1	0	6		
	Ellipsoidal ..	6	0	4	2	0	6								
5 days	Flat							6	0	3	3	0	6		
	Hemispherical									6	0	2	4	3	3
	Ellipsoidal ..	6	0	3	3	0	6								
7 days	Flat							6	0	6	0	0	6		
	Hemispherical									5	1	1	5		
	Ellipsoidal ..	6	0	5	1	1	5								
14 days	Flat									6	0	0	6		
	Hemispherical									6	0	4	2	0	6
	Ellipsoidal ..	6	0	2	4	0	6								
21 days	Flat									5	1	1	5		
	Hemispherical									6	0	1	5		
	Ellipsoidal ..	6	0	2	4	2	4								
28 days	Flat									6	0	0	6		
	Hemispherical									6	0	2	4	0	6
	Ellipsoidal ..	6	0	1	5										
35 days	Flat									6	0	0	6		
	Hemispherical							6	0	1	5				
	Ellipsoidal ..	5	1	1	5										
70 days	Flat							6	0	4	2	1	5		
	Hemispherical							5	1	3	3	1	5		
	Ellipsoidal ..	6	0	2	4	0	6								

THE EVALUATION OF SHEET FOR DEEP DRAWING

By
ROGER PEARCE,
B.A., B.Sc. (Oxon.)*

(This is one of the series of lectures presented at the Wolverhampton and Staffordshire College of Technology under the general title of "The Technology of Deep Drawing and Pressing")

THIS paper describes the evaluation of sheet as practised in the Pressed Steel Co. Ltd., and, in most motor-car-body press shops.

The metal used is bought to the specification, "To make this pressing satisfactorily with not more than x per cent scrap." A representative of the supplier has full access to the blueprints of the part and the tools to be used and from his study of these he then specifies to his company the grade of metal to be supplied. If it makes the pressing satisfactorily, welds satisfactorily and goes through the paint shop without trouble, then it is good and no further questions are asked. If, however, it gives trouble in the production of the part for which it was purchased, then it is tested in the laboratory and the results evaluated in an attempt to find the cause of the trouble.

The testing procedure used is far from being routine. Material is not brought in from the shop and subjected to a stereotyped test and a firm answer given. The test, in fact, is almost a small investigation in itself. All the testing machines available are used if necessary and information of real value may be obtained. By this means it is hoped to educate ourselves and to help our suppliers to produce the material required. Why is this method adopted? The answer is that there is only a limited quantity of the best steel and this must only be used for the most difficult pressings. If an elaborate specification, calling for certain mechanical properties, etc., was given, then quite obviously it would always be in excess of the properties required, to be on the safe side. In this way, good steel would be wasted on jobs which could be made from a lesser grade of material.

Testing of the material before it is issued to the press shop, pre-testing, will be dealt with here. In the Pressed Steel Company in 1959 about 200,000 tons of sheet steel were used and the task of pre-testing even one tenth of this defies imagination. The metallurgical laboratory did, however, investigate about 250 batches of steel, which caused trouble in the press shop. These tests would be concerned with, at the most, 4,000 tons of steel. Coming back to our previous figures, to pre-test one-tenth of the sheet steel purchased would involve increasing the staff four or five times and it is clear that this is not really a very good idea, for with the existing system, production was maintained. It is apparent therefore, that pre-testing of sheet steel, is rather a waste of time in a motor-car-body press shop.

This paper is concerned with sheet rather than strip, that is, material over 18 in. wide, and the author will confine his remarks primarily to steel, although naturally many of the same factors apply to non-ferrous metals.

Available Methods of Test

The available methods of evaluation can be divided into two groups *viz.* fundamental methods and simulative methods, and these can be expanded as follows. The fundamental tests are as follows:

(*a*) Tensile test.
(*b*) Hardness tests.
(*c*) Bulge test.
(*d*) Chemical analysis.
(*e*) Metallographic examination, which can be divided into:
  (i) inclusions, and
  (ii) grain-size and shape.

The second group of tests—simulative tests—are as follows:

(*a*) Erichsen or Olsen Test.
(*b*) Cup-forming tests like the Swift Test.
(*c*) The hole-widening test.
(*d*) The wedge-drawing test.
(*e*) The bend test.

Tensile Test

The most convenient test-piece to use in this test is the test-piece A1 described in B.S.S. 18, which is 0.75 in. wide and has a gauge length of 8 in. The specimen is pulled axially in a tensile-testing m .h .e until it breaks. During the test a load-e' gation diagram is drawn on an autographic recorder. A typical curve is shown in Fig. 1, where the point A is the yield point, the point B the limit of the plastic range before necking begins and the point C the point at which fracture occurs. During the test

* Chief Metallurgist, Pressed Steel Co. Ltd.

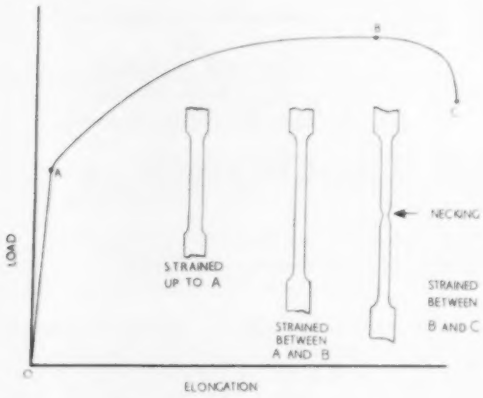


Fig. 1.—Typical tensile-test curve

the load at point A is recorded and also the breaking load of the test-piece. After fracture the tensile test-piece is removed from the machine and various elongations measured. From the curve itself, certain conclusions can be drawn, for instance, whether the steel is annealed last, whether it is aged rimming steel, etc. An intelligent guess can be made as to whether the material is stabilized steel. The factors measured from the tensile test using this 8-in. gauge length specimen are as follows:

(i) Yield point.
(ii) Tensile strength.
(iii) Ratio of yield point to tensile strength.
(iv) Total elongation over 8 in.
(v) General or uniform elongation over 6-in. part of the gauge length which does not include the fracture.

This property in conjunction with the tensile strength indicates whether the material has been properly processed, for it is known roughly what range these two figures should fall between. The yield-point to tensile-strength ratio is a very useful figure for it gives an idea of the slope of the load-elongation curve. A low yield to ultimate-strength ratio indicates a rising curve, which is associated with metal of good pressing properties, while a high yield to ultimate-strength ratio indicates a short flat plastic portion of the load-elongation diagram associated with bad pressing properties. This is a most important parameter and one which, often, is not fully understood, even by the sheet-metal suppliers. The point is that a comparatively small amount of cold reduction may not affect elongation figures to a great degree, but will have a marked effect on the yield-point to tensile-strength ratio and thus make the material unsuitable for pressing. It is possible that another material which has worse elongation figures, but has a lower yield point and

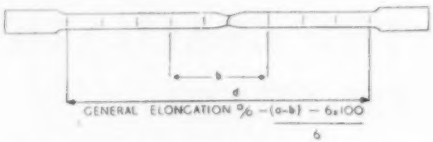


Fig. 2.—Diagram of general elongation measurement

a lower yield to ultimate-strength ratio, may be acceptable.

Total Elongation Over 8 in.

This total elongation of the test-piece is really a complex figure and one which is not viewed to-day as being very useful, as it contains both the uniform elongation of the test-piece and also the local elongation, including the necking down where the test-piece broke, both these values being mixed together. Recently more attention has been given to the general elongation, which is the 6 in. not associated with the fracture; this is illustrated in Fig. 2. This general elongation figure is a measure of the metal's ability to give uniform extension which is very useful for making motor-car-body types of pressings. It must be remembered that in the tensile test only simple tensile strain is imposed on the material, while in the act of making a pressing, stretching is going on in different directions under biaxial tension, and so the actual figures from the tensile test cannot be applied directly to a pressing. Nevertheless, experience over the years in the comparison of test results with press performance has enabled this figure to be used to differentiate between good and bad material. In addition, of course, the frictional effects involved in making a pressing are not taken into account in any way by the tensile test and I can only say that experience again makes it possible to say that a material with a low yield-to-ultimate ratio, coupled with a good general elongation, is needed.

Elongation on 2 in.

This figure includes the fracture of the test-piece and really consists of the general elongation which has been given to this part of the test-piece, as to all the rest, during the tensile test, and imposed upon this, the extra elongation occurring during the formation of the neck and fracture. Strictly speaking then, the 2-in. elongation is again a composite figure and may be disregarded in the same way as the 8-in. figure, but empirically it is found that a high 2-in. elongation figure is another good factor for the production of satisfactory pressings. I have placed great emphasis on the uniform extension of material and it can be seen that this must be a very important figure for the production of large pressings of the motor-car-body type. It is a source of amazement to me that some metal suppliers persist in using the 2-in.

test-pieces to obtain results which are then used as a measure of the suitability of their their material for the production of large pressings. The time has come when the 8-in. test-piece should universally be used for testing metal to be used for pressings of this nature.

Chemical Analysis

It is desirable to have a complete chemical analysis of any steel under investigation, but it is not always possible to analyze in a reasonably short time for, say, C, Mn, Si, S, P, N, O, and trace elements. Nevertheless, a routine analysis for, say C, Mn, Si, S, P, can help to clear up certain points. The carbon content of extra-deep-drawing grade steel is usually about 0.05 per cent, and for stabilized steel a little higher. A carbon content of 0.08 per cent is the ideal limit for satisfactory high-speed resistance welding. Very low manganese can result in lack of tenacity in steel with otherwise good properties. High sulphur content can be a reason for very fine grain-size, which in turn gives a longer yield-point elongation, and so more persistent stretcher-strain.

Metallographic Examination

This is really a grain-size and shape examination and a search for inclusions and carbides. The grain-size of extra-deep-drawing grade steel should be about A.S.T.M. 7. An elongated grain structure can be a check for stabilized steel. An elongated grain structure which was originally equi-axed would indicate excessive cold reduction.

Inclusions are often an explanation of bad transverse elongation figures, both general and over the 8-in. gauge length.

The presence of cementite if associated with grain boundaries is deleterious to all elongations both longitudinal and transverse, while massive cementite in the rim (*i.e.* on the edge) may be the cause of bad surface on a finished pressing.

Hardness Testing

It is found that all forms of hardness testing are too crude to tell anything very significant about the behaviour of sheet steel in a complicated pressing. Hardness testing is sometimes useful for non-ferrous metals which are far more uniform in properties than is steel. For aluminium and some of its alloys and for brass and copper, a hardness value can correspond quite closely to other mechanical properties and therefore it can be used for the assessment of, for example, strip, for the production of simple small pressings, of the type produced on automatic presses.

Hydraulic Bulge Testing

A criticism of any tensile test is that stretching is only done in one direction, while in a press the metal is subjected to multi-directional forces. It is disappointing then that the hydraulic bulge test has been neglected. It can be classed as a fundamental test for measuring stretching and is quite distinct from any cupping tests, as in the bulge test no friction is involved. The test now described is from work carried out by *Mellor* and *Loxley* at Sheffield University. They used metal 0.036 in. thick and a bulge diameter of 10 in. Before bulging, the circular blanks were marked with ink circles at intervals of 0.2 in. in order that the details of the extension over the surface could be measured. During the whole operation the maximum straining occurred at the pole of the bulge, and decreased gradually towards the clamping ring. This work was not carried out to develop this test for metal assessment, but some of the generalizations which are drawn from it are of interest.

(1) Annealed metals show a large increase in strain at constant or decreasing pressure before a narrow neck finally occurs very close to the point of fracture. No obvious broad necking occurs.

(2) Work-hardened materials fracture under increasing pressure without showing any unstable plastic flow.

(3) Hydraulic bulging gives rise to a high degree of plastic strain before fracture with both annealed and cold-rolled material. While this is to be expected of annealed material, it is somewhat unexpected in the case of a cold-worked material which gives poor elongation values in the simple tensile test.

It seems that this rather neglected test should be developed further.

Simulative Tests

Olsen Test

This is a cup-stretching test in which a relatively large blank is tightly gripped between blankholders while a punch is pushed into it until visual observation shows fracture has taken place. The height of the cup at fracture is measured and the load at fracture recorded. The test is simple and quick, but suffers from certain disadvantages. First, it is a stretching test and as such only measures one aspect of pressing. Second, as the cup is so small it cannot really simulate the large shapes produced in the press shop. Third, it is very sensitive to gauge of material, due again to its smallness.

It can be seen, therefore, that it is unsuitable as a test for metal for large press-work, and it may be noted that as it is predominantly a stretching test, neither is it suitable as a test for metal destined for the production of deep-drawn parts.

Hole-widening Test

This test is carried out on a press and consists of forming a flat-bottomed cup from a blank with a standard hole in the middle. The cup is drawn until a split occurs from the edge of the hole.

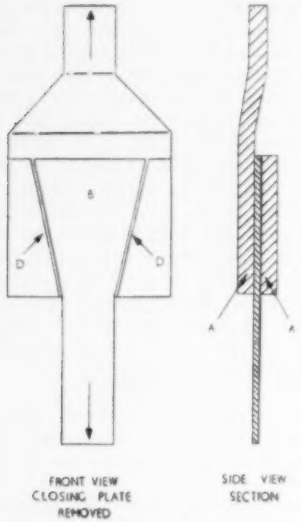


Fig. 3.—Diagram illustrating wedge drawing test

The factor measured does not seem to bear much relation to any particular happening in normal press-work and, of course, it is well-known that conditions of edges produce strange results.

Nevertheless, it is possible that it may have special applications in certain laboratories where it may simulate some production condition more closely than any other test.

Bend Test

As bending is an important part of any deep-drawing operation, it is necessary to mention bend tests. Unfortunately, in deep drawing, bending of the metal over the die radius takes place in tension, and so there is no correlation between simple bend results and the sort of bending which occurs during a deep-drawing operation.

All that can be said for this test is that it will serve to study metal which is to be used for the production of a simple flanged part.

Wedge Drawing Test

In this test a wedge-shaped piece of metal is pulled through a die as shown in Fig. 3. The object of the test is to determine the maximum length of the tapered part which can be successfully drawn; test pieces of regularly increasing size are used.

The disadvantages of this test are: (1) it disregards the bending and unbending which takes place in a drawing operation; and (2) it ignores the frictional effects associated with this bending.

Furthermore, the unusual frictional effects between the edges of the test-piece and the die are very high, and these cast doubt on the reliability of the test.

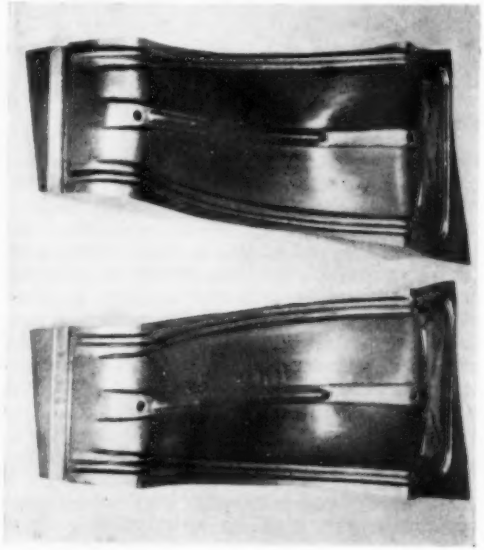
Cup-drawing Tests

It is very important that the difference between the cup-drawing test and the Olsen type of test described earlier is appreciated. In the latter, the metal is prevented from drawing to any real extent by gripping it tightly between blankholders or by a very large specimen in relation to the indentation made, which discourages metal flow by friction. In the cup-drawing type of test the blank is a definite size and the material is rated by the maximum blank diameter which will draw without splitting. This test is then a real small drawing operation using the same principles as are used in the factory for the production of actual pressings and so it is natural that such a test should have for some years been regarded as a promising way of providing a practical guide to the ability of metal to behave satisfactorily under the press.

Theory suggests that the cup-drawing tests should provide a reliable assessment as these tests subject material to the factors involved in deep drawing, stretching, bending drawing and friction and should be the ideal type of tests for assessment.

Obviously the shape of the punch is of prime importance. Early tests using a flat-bottomed punch with small radius found practically no correlation between press-shop performance and test results. This is because the sharp radii on the punch, in addition to friction, protect the metal under the head of the punch, reducing the amount of stretching over the punch head to almost nothing

Figs. 4 and 5.—Panels produced in freshly-processed and (bottom) aged steel



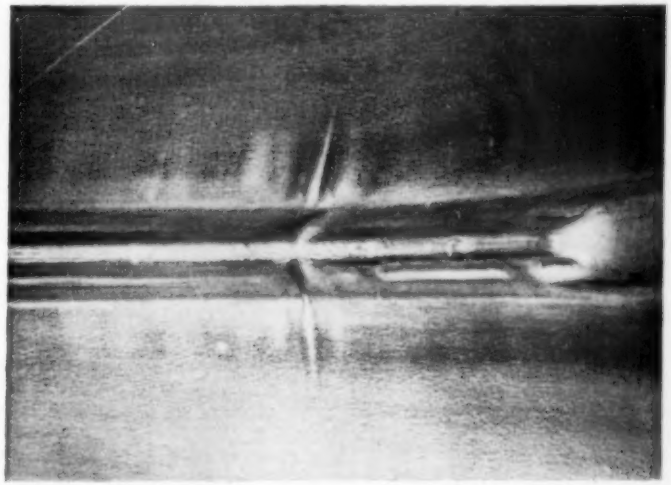


Fig. 6.—Panel in Fig. 4 at higher magnification

This is clearly a useless test for metal which, in practice, is to undergo appreciable stretching over the head of the punch.

It seems clear, therefore, that no single punch contour can be used for rating sheet metal in a cup-drawing test. The punch described above is useful in the case of deep-drawn articles like certain holloware, but other shapes must be considered for motor-car-body presswork. The hemispherical punch is more appropriate for this type of pressing, as the metal over the punch head receives a large part of the drawing load and stretches fairly freely, only being restricted by friction.

A hemi-ellipsoidal punch—a more "pointed" punch still—shows better differentiation than the hemispherical punch between steel of differing mechanical properties.

An example from this work can be given. Freshly-processed steel (designated RVN) was used to make a certain pressing, and other blanks from the same lift were aged at 100° C. for 1 hour to give quite different properties. The second batch of steel—the aged material—was unsuitable for this panel even with press adjustments. The mechanical properties of the steel were as shown in Table I.

The condition of the pressings produced is shown in Figs. 4, 5, 6 and 7. These tests show the sensitivity of the production press to changes in properties and the task in front of anyone trying to establish a simulative test. However, B.I.S.R.A. set up a committee some years ago to study the cup-drawing test and they prepared a standard test procedure and it is now believed possible to obtain agreement between different cupping presses by following this procedure. This is a step in the right direction, for the varying opinions held concerning cupping presses are probably due to the fact that there has been no agreement on the precise method to be used in carrying out cupping tests. Now that the I.D.D.R.G. is in existence and testing procedure is internationally agreed, it may be possible to reach a decision on the true value of this type of test.

TABLE I

	RVN	Non-aged	Aged
Yield Point	L*	12.3	16.0
	T†	12.5	15.5
Ultimate Tensile Strength	L	21.0	21.2
	T	21.2	21.3
2-in. Elongation ..	L	46.5	41.0
	T	44.5	44.0
8-in. Elongation	L	33.3	29.5
	T	30.5	29.7
General Elongation ..	L	29.0	25.7
	T	25.8	25.0
Y.P./U.S.	L	58.7	72.5
	T	62.6	75.4
Swift Number (hemispherical)		48.0	48.0
Swift Number (flat) ..		45.0	45.0

*Transverse †Longitudinal

Press Shops

In the press shop metal is formed in three ways. These are: (1) stretching; this is stretching in all directions over the head of the punch: (2) bending; this is extension caused by plastic bending under tension; and, (3) drawing; radial extension accompanied by circumferential shrinkage. This can be appreciated from Fig. 8. Consider the piece of metal A, B, C, D. As the punch descends all this must pass over the comparatively small space C. D, as it flows over the radius of the die. Thus, all the metal of the segment will have to shrink circumferentially to enable it to flow over its appropriate part of the die radius. It can be seen why the

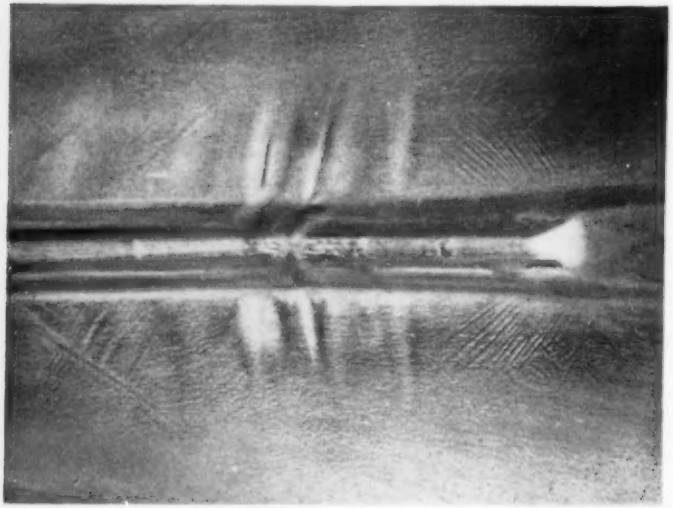


Fig. 7 (left).—Panel in Fig. 5 at higher magnification

Fig. 8 (below).—Diagram illustrating metal movement during forming

term "drawing" is used for this process, becauses the deformation which takes place is the same as in wire drawing. So, three of the things which happen to a piece of metal when it is pressed have been described. It has been subjected to stretching, bending and drawing. Now to enable stretching, bending and drawing to take place in such a way that the final result is what is required, there are two other things to consider: (1) blankholder pressure; and (2) lubrication.

Blankholder Pressure

Quite simply, blankholder pressure is the pressure applied by the blankholder and the die on the flat surface of the metal as it is pressed. There is a lot of empirical information on this subject in most press shops, and control of the blankholder friction is often the deciding factor in the manufacture of difficult pressings of complicated shape. Crudely, of course, the blankholder load is necessary to prevent wrinkling of the blank, but must not be high enough to restrain the metal to such a degree that it splits before any drawing-in takes place.

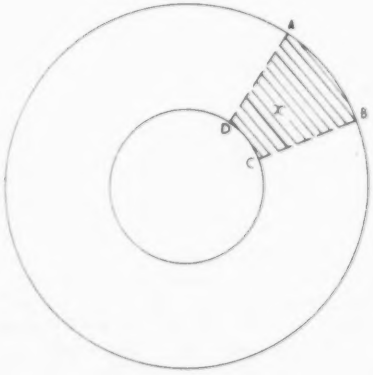
Lubrication

For the lubrication of difficult pressings usually a filled drawing compound is used, rather than a plain oil and this is applied by the operator with a wide brush or roller to the areas of the blank where, by experience, it has been found that lubrication is necessary. In this way, the metal can be made to draw-in where required, while in other areas, for instance, on the punch itself, frictional forces can be made use of to hold the metal as required. If the three processes mentioned, *i.e.* stretching, bending and drawing, take place when a complicated pressing is made, and everything goes according to plan and the mechanical properties of the material are right, then a satisfactory pressing is produced. If all these factors do not combine in the correct way, the panel may split, or buckle and form wrinkles, and whatever adjustments are made to the blankholder pressure, or to the lubrication, these faults cannot be remedied.

Where splitting is concerned, the author considers that elongation of the metal is the factor which mostly affects this trouble, and that, generally speaking, it is material with a high uniform elongation that gives the required result.

Another kind of splitting which is encountered is that which takes place with the soft metals and occasionally with unusually soft stabilized steel. This is where the frictional forces form a very large part of the drawing load and, in press shop parlance,

(*Continued in page* 660)



The Problem of CUMULATIVE FATIGUE DAMAGE IN SHEET

By T. R. G. WILLIAMS, M.Sc.* and D. H. HUGHES, B.Sc.*

Introduction

THE problem of the accumulation of fatigue damage under conditions of repeated stress cycles with amplitudes which vary more or less randomly over a relatively wide range has been given considerable attention in recent years. The main impetus for this work has been provided by the aircraft industry due to the need of predicting fatigue life in aircraft structures. The problem of fatigue induced by engine noise—("sonic fatigue")—is particularly important in the sheet panels of the aircraft fuselage and tail plane and Fig. 1 shows an example of such a structural failure.

To combat fatigue it is necessary to have many different types of information :—

1. Loads encountered and their frequency of occurrence.
2. Distribution of loads in the structure.
3. Means of interpreting existing sinusoidal S/N fatigue curves for application to variable load conditions. Much work has been directed to programme loading of components under conditions simulating operating conditions, but valuable though the information is, it does not meet the fundamental need of the designer. The following excerpt from the discussion on fatigue at the London Conference[1] summarizes the position :—

"Few engineers concerned with failures under repeated load will dispute the value of programme testing as advocated by the author, for manufactured parts or structures. However, the stage at which a cumulative damage rule was most needed was at the drawing board. Designers and stressmen had to be able to put pencil to paper to design a new component months and perhaps years before that component could be programme tested. It would seem, therefore, that the utility of the programme loading method to the designer must depend largely upon the availability of curves and statistics for different materials, under different load sequences and stress concentrations. This would entail an enormous amount of testing on expensive machines and although that might well be worthwhile, it did in a sense avoid the fundamental problem of cumulative damage which was how to predict behaviour under variable stress amplitudes from the ordinary S/N curve, a curve which was relatively cheap to obtain and of which there was a considerable amount of accumulated information." (*Levy.*)

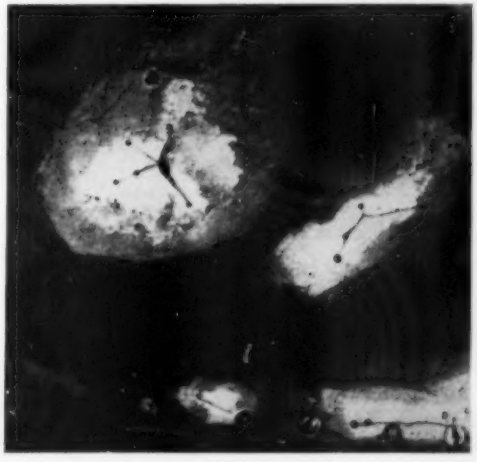
* The University, Southampton, Dept. of Mechanical Engineering

Review of Developments in the Estimation of Cumulative Fatigue Damage

Since the London Conference when the work of *Hooke* and *Head*[2] revealed the inadequacy of *Miner's*[3] rule in predicting fatigue life under random loading conditions, a great effort has been made to derive a practicable law for assessing cumulative fatigue damage under variable loading conditions.

In the work reported by Hooke and Head a notched test-piece was subjected to reverse bending and excited within its range of natural frequency. Experimental results were compared with theoretical predictions of fatigue life based on Miner's Rule in its severest form, *i.e.*, by considering each

Fig. 1.—Typical example of "sonic fatigue" failure



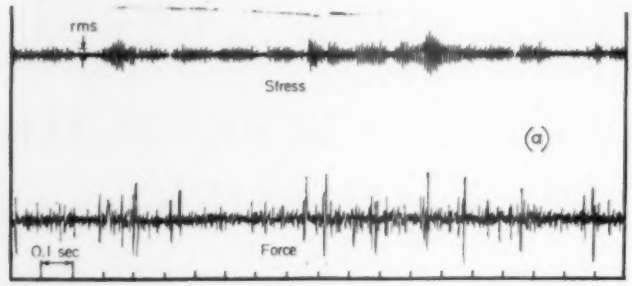
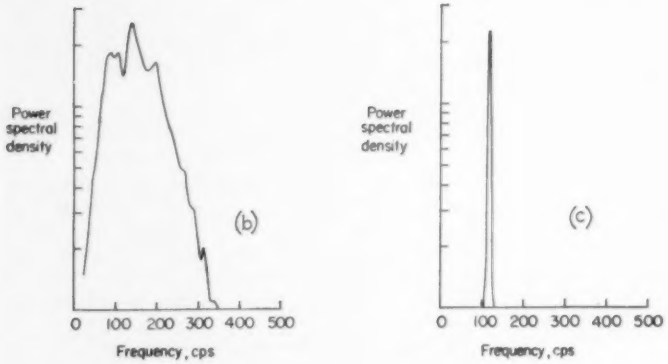


Fig. 2.—Fatigue-test data for notched test-pieces subjected to reverse bending within their range of natural frequency



extremum as a half cycle of amplitude equal to the deviation of the extremum from the mean stress.

$$N = -\int \frac{1}{\frac{dp(S)}{N_s(S)}}$$

where N = predicted fatigue life in cycles,
p = probability of a given stress value occurring, and
$N_s(S)$ = number of cycles to failure for varying stress levels as revealed in the S/N curve.

Table I is a summary of the results obtained.

TABLE I

Average peak stress	11,820 lb. per sq. in.	12,900 lb. per sq. in.
Average fatigue life cycles :		
Experimental	2.0×10^6	1.15×10^6
Predicted (Miner) ..	6.9×10^6	3.4×10^6
Ratio : $\frac{\text{Predicted}}{\text{Experimental}}$ ..	3.45	2.69

The results showed that Miner's Rule even applied in its severest form, predicted lives up to $3\frac{1}{2}$ × the experimental results obtained. The divergence between predicted and experimental life was less at the higher stress levels.

Recent work reported by *Fralich*[4] contradicts the results of Hooke and Head. Notched test-pieces of 7075-Al alloy were used and subjected to reversed bending within their range of natural frequency. Fig. 2 (*a*, *b*, *c*) shows that under these conditions the specimen acts as a narrow-band filter at its own natural frequency.

Fig. 3 shows the results obtained.

Comparison between random load tests and constant amplitude tests is made with R.M.S. of peak stresses as ordinate and time to failure as abscissa. In order to make the results of the constant amplitude tests obtained from rotating cantilever test machines, comparable with the random loading data, the constant amplitude results are expressed in terms of an equivalent time to failure based on the natural period of vibration of the test-pieces. At high stresses the random loading gives longer life than the constant amplitude tests and *vice versa* at stress levels near to and below the fatigue limit. For equal intervals of time the cumulative change in stress will be greater in sinusoidal than in random loading, as a high positive peak in the latter is usually succeeded by a small negative peak, and a shorter fatigue life would have been anticipated with the constant amplitude tests under these conditions of comparison. It therefore appears that an occasional high peak at the low R.M.S. comparison level has a very large damaging effect in fatigue whereas at the high R.M.S. comparison level, variations in peak stress values are not so injurious to fatigue life.

A theoretical assessment of fatigue life is also made in a similar manner to that utilized by Hooke

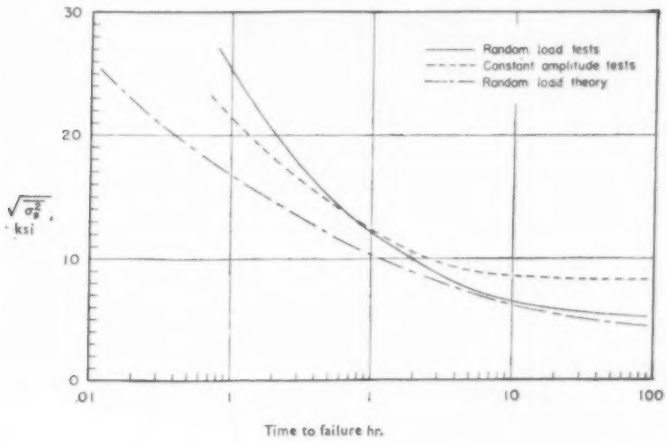


Fig. 3.—Results of tests with conditions as in Fig. 2

and Head. Contrary to their results, however, Miner's Rule under-estimates life at the high R.M.S. level and predicts life accurately at the low R.M.S. levels. There seems to be no valid explanation of this contradiction and further work to elucidate this discrepancy is required.

A method of utilizing Miner's relatively simple concept of linear damage has been proposed by *Freudenthal*(5). This involves the development of "fictitious S/N" curves by the intermittent application of high stresses to break down the dislocation networks formed under constant stress amplitudes, and thus to simulate the conditions obtaining under variable load conditions. Fig. 4 shows a typical fictitious S/N diagram and Fig. 5 the discrepancy between estimated and observed fatigue life in 2024 aluminium alloy. At high stresses and low cycles Miner's Rule is reasonably accurate but at low stresses the Miner's estimate of life is far too optimistic.

The physical model adduced by Freudenthal in support of his technique is not however appropriate to the 2024 aluminium alloy upon which his results are based. Striations are not observed in the metallographic examination of the fully aged high-strength aluminium alloys during fatigue life, and no significant damage has been reported in the path of a propagating crack(6) (*see* Figs. 6 and 7).

Recent Russian work(7) has shown a discontinuity in the S/N curve of a Duralumin-type aluminium alloy suggesting that an abrupt phenomenalogical change in the mechanism of fatigue occurs with varying stress levels (*see* Fig. 8). This work seems to support Freudenthal's claim that a change in method of fatigue deterioration occurs with changing stress level, although the change is not from one of "alternating plasticity" at high stresses to fine slip and striation bands at low stress levels.

Freudenthal assumes that by using a fictitious S/N curve a linear damage law will represent the conditions sufficiently accurately for predicting fatigue life.

Shanley(8) has attempted to circumvent this assumption by developing a formula for the "effective stress" of the loading sequence based on constant strain fatigue data, and involving a transformation from dynamic strain to stress.

Shanley's method of assessing cumulative damage is based on the following facts :—

(*a*) When cyclic plastic strains of constant amplitude (ε) are applied in fatigue testing the ε-N diagram plots as a straight line on log-log paper.

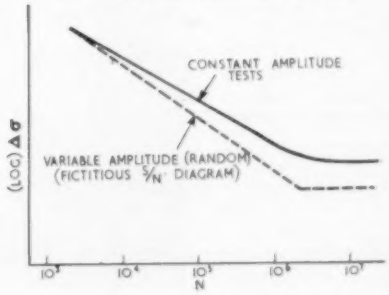
(*b*) The ε-N curves for widely different materials and testing temperatures fall within a narrow band and have approximately the same shape.

(*c*) Fatigue damage under cyclic strain of constant amplitude is linear.

He derives an expression for crack growth in fatigue which fits the experimental data reported by *Coffin*(9), *i.e.*

$N^{\frac{1}{2}} \triangle \varepsilon_p = c$ where N = cycles to failure, $\triangle \varepsilon_p$ = plastic strain and c = constant.

Fig. 4.—Typical fictitious S/N diagram



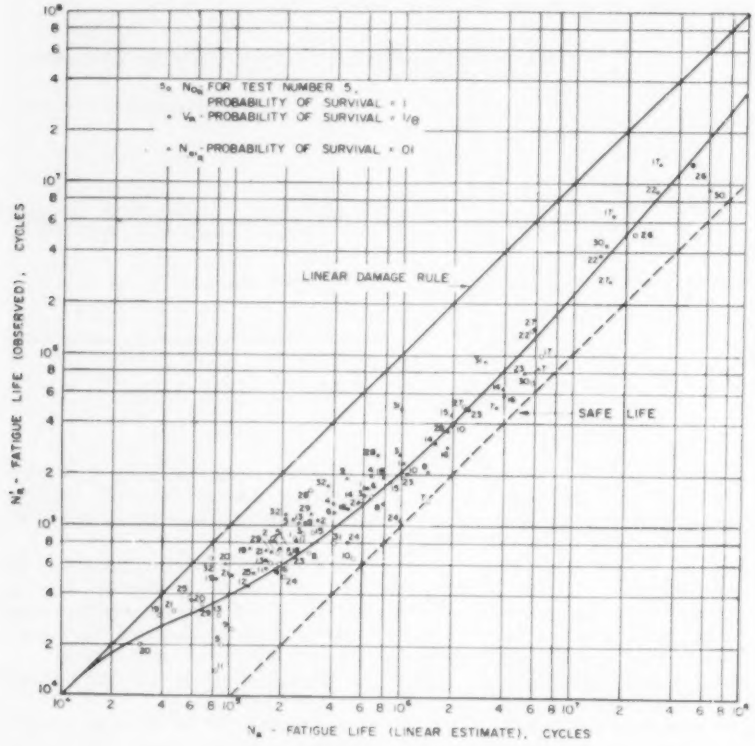

N_{0_5} FOR TEST NUMBER 5,
PROBABILITY OF SURVIVAL = 1
$V_{/e}$ - PROBABILITY OF SURVIVAL = 1/e
$N_{0.1}$ - PROBABILITY OF SURVIVAL = 01
LINEAR DAMAGE RULE
SAFE LIFE
N_R' - FATIGUE LIFE (OBSERVED), CYCLES
N_R - FATIGUE LIFE (LINEAR ESTIMATE), CYCLES

Fig. 5.—Discrepancy between estimated and observed life in 2024 aluminium alloy

Fig. 6 (×450).—Path of fatigue crack through unetched and electropolished surface of a high-strength Al-Zn-Mg-Cu alloy

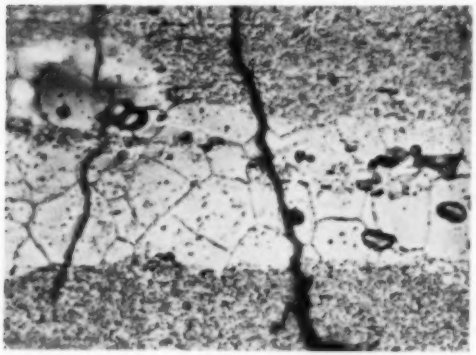


Fig. 7 (×250).—Path of fatigue crack through etched microstructure of high-strength Al-Zn-Mg-Co alloy (etched in Wasserman's reagent)

This equation gives a slope of $-\frac{1}{2}$ when log $(\triangle\varepsilon_p)$ is plotted against log N and the slope is independent of material properties.

To apply this theory to the assessment of cumulative fatigue damage, the following information is required :—

1. Relationship between plastic strain and stress under dynamic fatigue loading conditions.

2. True fatigue limit under dynamic varying fatigue conditions.

Shanley assumes that strain softening or hardening is complete during a small fraction of fatigue life and that the stabilized plastic strain can be used satisfactorily. Furthermore, he states that the relationship $\triangle\varepsilon_p = f(\triangle\sigma)$ where $(\triangle\sigma) = \frac{1}{2}$ amplitude of cyclic stress is a power function, *i.e.*

$$(\triangle\varepsilon_p) = (\triangle\sigma)^x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

He then suggests the use of the *effective stress* concept defined as that value of stress increment which if applied at constant amplitude will give the same N_p as the variable amplitude loading.

The effective stress $\triangle\sigma_e$ is obtained as follows :—

Fig. 8.—S/N curve for Duralumin-type alloy showing discontinuity

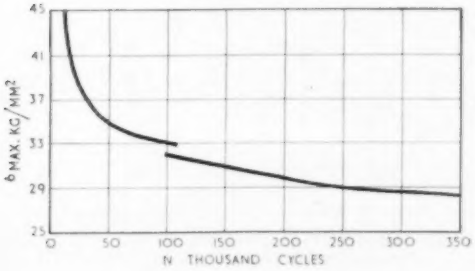
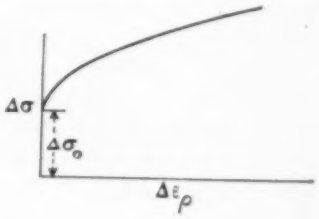


Fig. 9.—Curve showing relationship of $\Delta\varepsilon_p$ and $\Delta\sigma$ $(\Delta\varepsilon_p = C(\Delta\sigma - \Delta\sigma_o)^x$



$$N_p = \frac{\Sigma n_i}{\sum \frac{n_i}{N_i}} \qquad \text{(Miner's Rule)}$$

$$\text{Also } N_p = \frac{k}{(\triangle\varepsilon_p)^x} = \frac{k}{(\triangle\sigma_e)^x}$$

$$\frac{k}{(\triangle\sigma_e)^x} = \frac{\Sigma n_i}{\sum \frac{n_i}{N_i}}$$

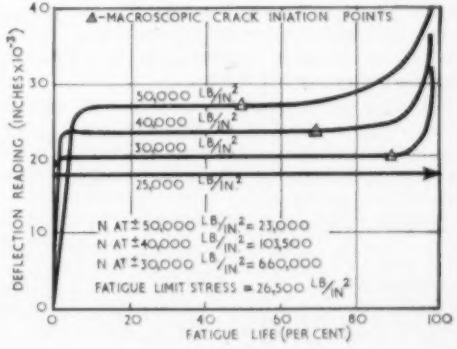
$$\triangle\sigma_e = \left[k \frac{\sum \frac{n_i}{N_i}}{\Sigma n_i} \right]^{\frac{1}{x}} \quad \text{But } N_i = \frac{k}{(\triangle\sigma_i)^x}$$

$$\triangle\sigma_e = \left[\frac{\Sigma n_i (\triangle\sigma_i)^x}{\Sigma n_i} \right]^{\frac{1}{x}}$$

It is suggested by Shanley that tests should be conducted in which specimens are subjected to spectrum loadings that are identical except for the omission of one or more of the smallest stress levels. This would establish the endurance limit values for variable amplitude loading.

The work of *Hughes*[10] indicates that for stress levels up to 60 per cent above the fatigue limit the deflection is constant for 75 per cent of the

Fig. 10.—Deflection curves for notched Wöhler reversed bending specimens. Material is normalized mild steel. $K_t = 1.44$



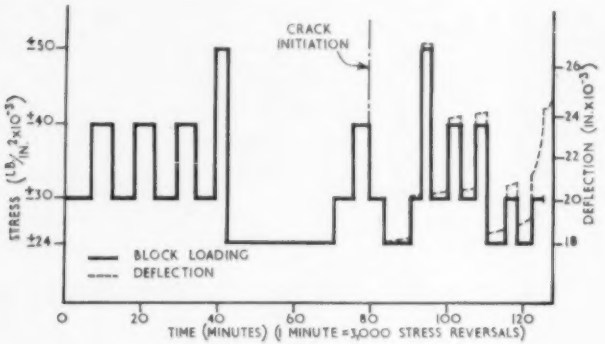
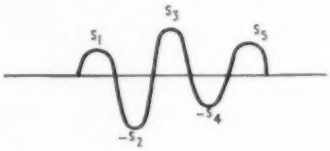


Fig. 11 (left).—Block loading record, showing return of deflection to original value until crack initiation

Fig. 12 (below).—Two parameters affecting fatigue life are the distribution of mean stress and the range of alternating stress derived by pairing together neighbouring positive and negative peaks

$$\sigma_m = \frac{S_1 + (-S_2)}{2}$$

$$\sigma_A = \frac{S_1 - (-S_2)}{2}$$



fatigue life, and below this stress level crack propagation effects are small (Fig. 10).

Furthermore block tests involving large variations in stress amplitude have revealed a constant relationship between dynamic stress and strain up to 80 per cent of fatigue life (Fig. 11).

Apart from the problems of obtaining a cumulative fatigue damage rule and of interpreting fatigue life from stress or strain data, there is the problem of assessing the response of structures to random excitation and of defining the relevant statistical distribution. There is general agreement that a Rayleigh distribution of peak amplitudes adequately describes the response of structures to sonic fatigue provided a realistic upper limit to stress amplitudes is defined, *e.g.*, *Getline*[11] recommends a peak stress to R.M.S. ratio of 4. However, the more important information required for fatigue analysis is the distribution of the stress fluctuations.

In a recent paper *Schjelderup*[12] has suggested a method of analysing fatigue data to avoid the conservative estimates of life resulting from the application of Miner's Rule to a Rayleigh distribution of the peak stresses and of assuming that negative and positive peaks follow in succession. From data obtained on sonic fatigue tests with aircraft structures, he has considered two parameters affecting fatigue life—the distributions of mean stress and range of alternating stress derived by pairing together neighbouring positive and negative peaks (*see* Fig. 12).

Schjelderup has shown that whereas the incidence of peak stresses is represented by a Rayleigh distribution the variation in mean and alternating stress are best represented by Gaussian Distributions, so that

Probability of mean stress σ_m

$$= f_1(\sigma_m) = \frac{e^{-\frac{1}{2}\left(\frac{\sigma_m}{\sigma_a}\right)^2}}{\sigma_a \sqrt{2\pi}} \quad \ldots\ldots\ldots\ldots(1)$$

Probability of alternating stress σ_A

$$= f_2(\sigma_A) = \frac{e^{-\frac{1}{2}\left(\frac{\sigma_A - \sigma_e}{\sigma_b}\right)^2}}{\sigma_b \sqrt{2\pi}} \quad \ldots\ldots\ldots\ldots(2)$$

where σ is the normalized stress $\frac{S}{\bar{S}}$, σ_a is the normalized standard deviation of the mean stress and σ_b is the normalized standard deviation of the alternating stress and σ_e is the normalized mean alternating stress.

Thus the probability of occurrence of a mean stress σ_m and alternating stress σ_A is given by equation (3)

$$P(\sigma_m, \sigma_A) = f_1(\sigma_m) f_2(\sigma_A)\, d\sigma_m\, d\sigma_A \quad \ldots\ldots\ldots(3)$$

The number of occurrences in N cycles of mean stress σ_m and alternating stress σ_A is given by equation (4)

$$dn = NP(\sigma_m, \sigma_A) \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

and dD the incremental damage is Equation (5).

$$d\mathrm{D} = \frac{NP(\sigma_m, \sigma_A)}{N(\sigma_m, \sigma_A)} \quad \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

where $N(\sigma_m, \sigma_A)$ = cycles to failure at alternating stress σ_A and mean stress σ_m as obtained from a Modified Goodman Diagram.

The total number of cycles to failure N is that which produces a damage of unity and from Equation (5).

$$\frac{1}{N} = \iint_{\sigma_m\ \sigma_A} \frac{f_1(\sigma_m) f_2(\sigma_A)\, d\sigma_m\, d\sigma_A}{N(\sigma_m, \sigma_A)} \quad \ldots\ldots\ldots\ldots(6)$$

If fluctuations of mean stress are disregarded

(*Continued in page* 659)

The Problem of Cumulative Fatigue Damage

(*Continued from page* 658)

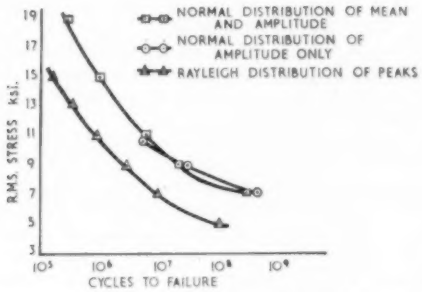


Fig. 13.—*Random fatigue curve for Alclad* 7076-*T6*

Equation (6) becomes :—

$$\frac{1}{N} = \int_{\sigma A} \frac{f_2(\sigma_A)\, d\sigma_A}{N_e(\sigma_A)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The results obtained are shown in Fig. 13 the conclusions being :—

1. Fatigue lives calculated on a Rayleigh distribution of peak stresses are shorter than those based on a Gaussian Distribution of Mean and Alternating stress.

2. There is no significant difference between fatigue life predicted, based on Gaussian distribution of alternating stress, and that based on both Gaussian distributions of mean and alternating stress.

These results encourage the belief that the calculation of the R.M.S. of stress fluctuations in structural response to sonic excitation and prediction of fatigue life from the results based on the Gaussian Distribution can provide a more accurate method of assessing cumulative fatigue under random load conditions.

Conclusion

1. Recently developed techniques for assessing cumulative fatigue damage although retaining the simple concept of linear damage proposed by Miner, do nevertheless require special material test data and fail to make use of the ordinary S/N curve.

2. Although it is established that the response of a structure to sonic excitation is characterized by a Rayleigh distribution of peak stresses, the more significant parameter of fatigue damage is the cumulative variation in stress amplitude.

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SIXTH INTERNATIONAL CONFERENCE ON HOT DIP GALVANIZING

THE sixth in the series of International Conferences on Hot Dip Galvanizing is to be held in Switzerland—at the Kursaal, Interlaken—from June 4 to 9, 1961.

The number of delegates attending the previous conferences at Copenhagen, Dusseldorf, Oxford and Milan has steadily increased and nearly 350 were present at the 1958 Conference held in Holland and Belgium in conjunction with the Brussels World Exhibition. Numbers at Interlaken are expected to be even bigger.

Three days will be devoted to technical sessions at which over 20 papers will be presented on works practice, the properties and corrosion resistance of galvanized coatings, the welding of galvanized steel, the metallurgy of galvanizing, after-treatments, and the heating of galvanizing baths. One session will also be devoted to sheet galvanizing. Preprints of the papers will be issued in French, German, Italian and English and there will be simultaneous translation into the same four languages at the technical sessions themselves.

Works visits will be arranged in conjunction with the Conference to general galvanizing plants in Switzerland and to sheet-, wire- and tube-galvanizing plants in Italy. Plant, equipment and materials supplied to the galvanizing industry will be exhibited by manufacturers in a room adjacent to the conference hall. The edited proceedings of the Conference will be published towards the end of 1961.

Those wishing to attend the Conference as delegates or to participate in the exhibition of plant, equipment and materials should write to the Z.D.A., 34, Berkeley Square, London, W.1.

The Evaluation of Sheet

(*Continued from page* 652)

the punch "knocks the bottom out" of the pressing, before drawing-in takes place.

As far as buckling is concerned, this is associated with yield-point to ultimate-strength ratio. (*See* Figs. 4, 5, 6 and 7.) A low yield-point is required to enable the sheet to stretch as early as possible in the drawing operation to give the shape required, before drawing-in has proceeded too far. In other words, the lower the yield point the longer the plastic range, other things being equal, so the more time the material has to make the part satisfactorily; or again, the lower the yield-point, the better the shape of the load-elongation curve from a pressing point of view.

Another very important property required for trouble-free press runs is good surface condition of the steel. Surface defects can broadly be divided into two classes; those which are associated with the ingot and those which are associated with the rolling process. Those associated with the ingot are surface laminations, pipe laminations, and defects arising from imperfect scarfing. In the second group come such things as coil breaks, chatter marks, sticker marks, fleck scale, etc. Another trouble associated with processing, which is occasionally experienced, is connected with the surface roughness produced on the steel sheet by the use of shot-blasted rolls. Normally this roughness varies, depending on whether the rolls are newly shot-blasted or at the end of their life, but it has sometimes been thought that a very heavy shot-blasted finish may be introduced by the supplier to mask certain defects. It has been found that this very heavy surface will, by producing different frictional effects between the blankholder and the sheet, give different pressing characteristics which involve a considerable amount of press adjustment before the material will press satisfactorily.

Nevertheless, any defect which is seen in the shop and can be certainly given as the cause of trouble is not usually a laboratory matter. If trouble can be sorted out before the laboratory need be called in, unnecessary testing is not carried out. If it is clear that the trouble is due, for instance, to surface laminations occurring on a part of the sheet which is highly stretched which gives rise to splits, then it is unnecessary to investigate the matter further. The matter is usually discussed at a commercial level and satisfaction obtained on both sides. The main requirements of sheet steel for the press production of motor-car-body pressings, are uniformity and consistency. Naturally, uniformly bad material is not wanted but uniformly average material will give less trouble in a press shop than some very good material mixed with some bad.

Conclusions

First, pre-testing is a snare, except in certain special cases.

Two groups of tests used for sheet-metal assessment were then described: fundamental tests and simulative tests. Among the fundamental tests, hardness testing is too crude and the hydraulic bulge test needs developing. This leaves the tensile test using an 8-in. test-piece and what are regarded as adjuncts to this, chemical analysis and metallographic examination. These tests, used and developed over the years at the Pressed Steel Co., are, in the author's opinion, the best method of assessment, but experience is required in the interpretation of the results produced. Admittedly, experience is required in the interpretation of any results, but perhaps more experience is required in the case of the tensile test than in most others.

Under simulative tests the Olsen test is useful as a rough guide, but is very sensitive to metal thickness.

The Swift Cupping Test is only in its infancy and shows more promise than any other simulative test, even though it seems at present not to be sufficiently sensitive to small changes in yield point which produce significant variations in the press-shop. The hole-widening test is somewhat suspect owing to the special conditions produced, and the bend test is only useful as a test for material to undergo a simple bend.

For the future, it is to be hoped that research work on testing, which has recently undergone a revival, will continue strongly. Much work is necessary on the Swift Test and this fact is realized by its protagonists. The hydraulic bulge test is a new field for exploration and the development of a new test which would evaluate work-hardenability would be very useful.

But at the moment, the tensile test as described would appear to be the best method of assessing the suitability of sheet metal for press work.

The author acknowledges the published work of the late Mr. G. Murray, from which some examples and some diagrams have been drawn.

OLD ENGINES UNDER STEAM

AT the Department of Science and Industry of the Birmingham City Museum, Newhall Street, Birmingham 3, arrangements have been made to put a number of old engines under steam on September 29, on which day the Museum will remain open until 9 p.m. Twenty whistles taken from railway engines will also be sounded. It is hoped that those unable to attend the " Steam Weekends " will avail themselves of the opportunity to be present on September 29.

SPOT WELDING

Low-Carbon Steel Sheet*

Details of Technique for Sheet 0·022 to $\frac{1}{8}$ in. in Thickness

Introduction

IN order to produce spot welds of uniform quality, size and strength, the machine settings used should be those at which any fluctuation in the welding variables will have a minimum effect on the welds. While under perfect conditions it is theoretically possible to maintain all the welding variables at precise values, this can never be attained in practice, particularly as some factors may be outside the control of the user, for example, fluctuations in line voltage. The use of machine settings which will give the values of welding current, weld time and electrode load which are recommended in Table I ensures that the effects of any uncontrolled variations will be at a minimum.

The range of thicknesses covered in this report are from 24 s.w.g. to $\frac{1}{8}$ in. (0.559 to 3.18 mm.); some details of conditions for spot welding of thicker material ($\frac{3}{16}$ in. and $\frac{1}{4}$ in.—4.76 mm. and 6.35 mm.—thick) are being prepared by the Association and will be available in a report number FR.6/36.

In the spot welding of low-carbon steels, many combinations of the welding variables can be used, all of which will give satisfactory results. The choice of a particular combination will be influenced by the capacity of the welding machine available, and by the composition of the steel which is to be welded. The recommended conditions are based on a large amount of experimental work carried out by the British Welding Research Association, coupled with the wide experience of members of the FR.6 Committee of the Association. A detailed discussion of the various factors governing the production of good-quality welds is presented in the following.

* Prepared by a panel of the FR.6 Committee of the British Welding Research Association on "Spot Welding of Steel" for the International Institute of Welding.

Materials

The material covered in these recommendations is clean, bright, low-carbon mild-steel sheet. As the thickness increases, the quenching effect due to the electrodes is reduced, and therefore higher percentages of carbon and other elements can be tolerated. The effect of any one element on hardening and embrittlement of the welds is dependent on the amount of the other elements also present. Therefore, the residual elements such as nickel, molybdenum, copper and chromium should be kept as low as possible, especially when the carbon content is towards the maximum, which varies from about 0.11 per cent max. for 24 s.w.g. (0.559 mm.) to 0.15 per cent max. for $\frac{1}{8}$ in. (3.18 mm.); but if the carbon content is low, appreciable amounts of the residual may be allowable (*e.g.*, in the analysis of the 24-s.w.g. steel quoted later, the Ni. per cent is as high as 0.14, but the C is low at 0.08).

Some typical analyses of sheet which has been welded satisfactorily are given below, and it will be seen that the carbon content for $\frac{1}{8}$-in. (3.18-mm.) material is considerably higher than that for 24 s.w.g. (0.559 mm.). It must be emphasized that these are typical compositions, and do not necessarily give maximum percentages of the various elements.

Typical Compositions

Thickness	24 s.w.g. 0.022 in. 0.559 mm.	16 s.w.g. 0.064 in. 1.63 mm.	$\frac{1}{8}$ in. 0.125 in. 3.18 mm.
C per cent	0.08	0.09	0.15
Mn ,,	0.36	0.42	0.56
S ,,	0.03	0.03	0.05
P ,,	0.02	0.04	0.09
Cr ,,	0.01	—	—
Ni ,,	0.14	—	—
Cu ,,	0.12	0.06	—

TABLE I—*Data for Spot Welding Two Equal Thicknesses of Low-Carbon Mild Steel Sheet*

Sheet thickness			Electrode tip dia.		Electrode load*		Welding current, in amperes weld time in cycles (50 c/s)						Average shear failing load ‖		Approx. dia. of fused zone		Min. distance of weld from edge		Min. weld pitch†	
							B		A		C									
in.	mm.	s.w.g.	in.	mm.	lb.	kg.	Current	Time	Current	Time	Current	Time	lb.	kg.	in.	mm.	in.	mm.	in.	mm.
0.022	0.559	24	$\frac{3}{32}$	3.97	190	86	5,000	5	5,000	10	5,000	20	530	240	0.15	4	$\frac{1}{4}$	6.4	$\frac{3}{8}$	9.5
0.028	0.711	22	$\frac{5}{32}$	4.76	275	124	8,000	5	6,500	10	5,000	25	800	363	0.18	4.5	$\frac{1}{4}$	6.4	$\frac{7}{16}$	11.1
0.036	0.914	20	$\frac{5}{32}$	4.76	275	124	8,000	10	6,500	15	5,500	30	1,100	499	0.18	4.5	$\frac{5}{16}$	7.9	$\frac{1}{2}$	12.7
0.048	1.22	18	$\frac{7}{32}$	5.56	375	169	9,000	10	7,500	20	6,500	40	1,400	635	0.22	5.6	$\frac{5}{16}$	7.9	$\frac{3}{8}$	9.5
0.048	1.22	18	$\frac{1}{4}$‡	6.35	500	226	10,500	15	9,000	25	8,500	40	1,550	700	0.25	6.4	$\frac{5}{16}$	7.9	$\frac{3}{4}$	19
0.064	1.63	16	$\frac{1}{4}$	6.35	500	226	9,500	15	8,000	20	7,500	50	2,200	798	0.25	6.4	$\frac{3}{8}$	9.5	$\frac{3}{4}$	19
0.080	2.03	14	$\frac{5}{16}$	7.94	770	349	12,000	20	10,500	30	9,000	50	3,700	1,678	0.31	8	$\frac{1}{2}$	12.7	1	25.4
0.104	2.64	12	$\frac{5}{16}$	7.94	700	349	13,000	20	11,000	40	9,500	80	5,400	2,450	0.34	8.8	$\frac{1}{2}$	12.7	$1\frac{1}{4}$	31.8
0.125	3.18	—	$\frac{11}{32}$§	8.73	1,400	635	15,500	20	13,000	40	9,500	100	7,400	3,357	0.37	9.4	$\frac{1}{2}$	12.7	$1\frac{1}{2}$	38.1

* 10,000 lb. per sq. in. (703 kg. per sq. cm.) tip area up to and including $\frac{1}{4}$-in. (7.9-mm.) tip diameter.
15,000 lb. per sq. in. (1,054 kg. per sq. cm.) tip area for $\frac{5}{16}$-in. (8.7-mm.) tip diameter.
A. Normal recommended condition.
B. Limiting condition for most efficient use of energy.
C. Limiting condition for low currents and long times.
† At closer pitches, increased current or time is required to offset the effects of current loss through previous welds.
‡ $\frac{1}{4}$-in. (6.4-mm.) tips are commonly used in practice, though $\frac{5}{16}$-in. (5.55-mm.) is nearer to $\sqrt{t}$ (where t = sheet thickness in inches).
§ An included angle of 140 deg. is recommended for $\frac{11}{32}$-in. (8.7-mm.) dia. tips.
‖ Specimen width $\frac{3}{4}$ in. for 24 s.w.g. (19 mm. for 0.559).
1 in. for 22 s.w.g. (25.4 mm. for 0.711).
$1\frac{1}{2}$ in. for 20 to 12 s.w.g. inclusive (38.1 mm. for 0.914 to 2.642).
2 in. for $\frac{1}{4}$ in. (50.8 mm. for 3.175 mm.).

Nugget penetration 0.65 t 20%
Max indentation 1/10
Electrode tip diameter = t inches to nearest 1/32
Nugget diameter = tip dia +10% -20%
Max sheet separation 1/10

Fig. 1—*Diagram of spot welds obtained with two equal thicknesses of sheet using conditions listed in Table I*

Normally, the maximum carbon permissible content for spot welding varies from 0.11 for 24 s.w.g. to 0.15 for $\frac{1}{8}$ in. (0.559 mm.).

Recommended Spot-Weld Dimensions

For welding two equal thicknesses of material use of the recommended conditions listed in Table I will result in spot welds as shown diagrammatically in Fig. 1. The weld nugget diameter is substantially the same as the electrode tip diameter, while the indentation and sheet separation are individually less than 10 per cent of the sheet thickness; the penetration of the weld nugget into each sheet will be from 40 to 80 per cent of the sheet thickness. Values of penetration, and nugget diameter relative to electrode-tip diameter generally increase within the limits given in Fig. 1 as the thickness of the sheet increases. The weld nugget is virtually a casting possessing a normal dendritic structure, and susceptible to defects such as porosity and shrinkage cracks.

Because it is not always possible to obtain exactly the current values quoted in Table I, the relationship of welding current and time is given in Fig. 2 for each thickness of material. Any of the appropriate relationships of current and time between lines B and C in this figure will give satisfactory welds.

Electrodes

Whenever possible, the electrodes which should be used for spot welding are those specified in British Standard 807* and the following requirements should be met.

* Electrodes supplied to B.S. 807 will have a standard tip diameter for a given shank diameter. This may necessitate machining to the correct tip size before the electrodes are put into service.

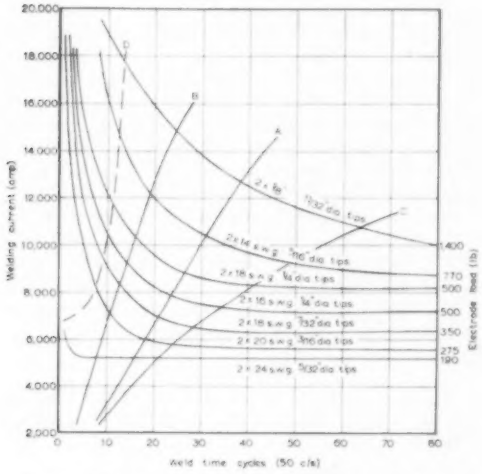
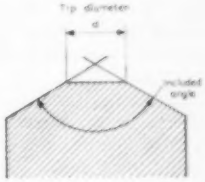


Fig. 2.—Relationship between welding current and time

Fig. 3 (right).-Recommended electrode tip shape and size



Electrode Tip Size and Shape

The recommendations in these documents are based on the use of a truncated cone electrode tip of the type shown diagrammatically in Fig. 3. There is no objection to the use of domed electrode tips but these are not in such general use in Great Britain for spot welding steel, and are rather more difficult to machine to the correct contour than a truncated cone with a flat tip. If domed electrodes are used, satisfactory welding conditions will probably differ from those given in Table I. The diameter of the flat of a truncated cone electrode to be used against any particular thickness of material may be derived approximately from the following formula :—

$$d = \sqrt{t}$$

where d is the electrode tip diameter in inches and t is the thickness in inches of the component with which the electrode will be in contact.

The use of this formula gives the sizes quoted in Table I to the nearest 32nd of an in. In service, the electrode tip diameter will increase, and it is recommended that not more than a 20 per cent increase in diameter should be permitted before re-machining to size. It may be possible, under certain circumstances, to tolerate a greater increase in tip diameter, but this can only be determined by experiment since it depends on component design and the welding conditions used.

Electrode Material

The material of which electrodes are made should possess high thermal and electrical conductivity and should retain its hardness at elevated temperatures. Hard-drawn high-conductivity copper quickly deforms under production conditions owing to the softening which occurs when it is heated. Several proprietary brands of copper alloys with improved mechanical properties at elevated temperatures have been developed for spot welding electrodes and the use of these is recommended.

Water Cooling

In order to keep the electrode temperature low, efficient water cooling must be provided to help dissipate the heat which is conducted to the electrode from the weld. The blind end of the cooling hole should be not more than $\frac{3}{4}$ in. (19 mm.) away from the electrode tip for 1-in. (25-mm.) body diameter electrodes, and not more than $\frac{11}{16}$ in. (17.5 mm.) for $\frac{5}{8}$-in. (15.9-mm.) or $\frac{3}{4}$-in. (19-mm.) body diameter electrodes. The end of the inlet tube should be at a distance not greater than $\frac{3}{8}$ in. (9.53-mm.) from the blind end of the water cooling hole, and it is advantageous for the end of the inlet tube to be cut at an angle as this reduces the possibilities of a blockage. The water flow through the electrodes should be at least $\frac{3}{4}$ gallon per min.

Included Angle

The included angle of the truncated cone is governed by the tip diameter to be used which, in turn, depends on the sheet thickness. For tip diameters up to and including $\frac{5}{16}$ in. (7.9-mm.) an included angle of 120 deg. should be used. For tip diameters greater than $\frac{5}{16}$-in. (7.9-mm.) an included angle of 140 deg. is recommended. The use of smaller included angles results in more rapid spreading of the electrode tips during welding and hence in more frequent machining of electrodes to reduce them to the correct size.

Electrode Pressure

The electrode pressure depends to some extent on the thickness of the material being welded. For thin materials, it should never be less than 10,000 lb. per sq. in. on the initial area of the electrode tip, and for material $\frac{1}{8}$-in. (3.18-mm.) thick, a top pressure of not less than 15,000 lb. per sq. in. is recommended. The corresponding values of actual electrode load in lb. and kg. are given in Table I. In most cases electrode load without the welding current actually flowing can be measured

by means of simple instruments commercially available. An approximation to the electrode load can be calculated in the case of air-operated machines from the air pressure and cylinder dimensions, provided that due account is taken of any back pressure which may arise from return springs, return air pressure, friction and inertia. It must be noted that the load on the weld will not be the same as the total electrode load if, due to initial component distortion, pressure is lost in bringing the parts into contact at the point where the weld is to be made.

The normal method of machine operation is for the electrode load to build up to as near as possible its final value before the weld current is initiated. The full electrode load should be maintained after the welding current has ceased to flow, in order to consolidate the weld nugget; this is discussed under the heading "Forge Time."

With many machines, it is possible to measure current and electrode load simultaneously by means of an oscillograph. This may be desirable in some cases, particularly where the machine has a variable electrode load cycle. The relationship of current and load can be extremely important in such applications, and the use of oscillographic recording is an invaluable aid when any troubles arise.

Welding Current

The values of welding current given in Table I are the R.M.S. (root mean square) values in amperes for continuous sinusoidal wave trains and refer to the current during the making of an actual weld. It is important that measurement of current in obtaining machine settings should be made as a weld is formed, since considerable differences exist between short-circuit currents and those obtained when the material is placed between the electrodes. The short-circuit current is always higher than the corresponding welding current, and this difference may be as great as 10 per cent of the welding current; the actual difference depends on the electrical characteristics of the welding transformer and the secondary circuit of the welding machine. The measurement of secondary current during welding may be done by a number of direct reading instruments (developed by the B.W.R.A.) or by use of an oscillograph(1). If no instruments are available, an approximation to the conditions of column B in Table I can be obtained by the following method. Set the weld time to the recommended value, and gradually increase welding current until excessive splashing occurs; at this point the current has been increased too much and a reduction to the point at which splashing ceases will give reasonably satisfactory welding conditions.

Column A, B and C, of Table I, and the corresponding lines, A, B and C, of Fig. 2, give three values of welding current with their associated weld times, of which the values in Column A are recommended for general application. If maximum efficiency in the use of energy is required conditions in column B should be used, but if expulsion of metal is to be avoided completely, it is essential that the material being welded should be clean and free from surface defects, and that the parts should fit well. The conditions listed in column C may be used with advantage for mild steel in which the carbon and manganese contents, and the percentage of other elements such as nickel, chromium and/or molybdenum are slightly higher than those quoted in the section on materials, or where surfaces are slightly rusty.

Weld Time

Weld time refers to the duration of the welding current and recommended values over a range of welding currents for various sheet thicknesses are given in Table I. Timers to control the duration should be capable of reproducing consistently the weld time for which they are initially set, and they may be calibrated by means of commercially available cycle recording instruments or by means of an oscillograph. (Details of methods devised by the B.W.R.A. are available in other publications.)(2)

Forge Time

The time for which electrode load is maintained at the full value after the welding current ceases is known as the forge time. Provided it is sufficient to allow consolidation of the weld nugget, no appreciable improvement is obtained by increasing the forge time. The forge time required increases as the material thickness increases, *e.g.*, approximately one-tenth of a second is sufficient when welding 16-s.w.g. (1.63-mm.), but when welding $\frac{1}{8}$-in. (3.18-mm.) thick material, forge times should be at least 1 second.

Fluctuations in the Value of Welding Variables

Spot-welding machines should be adjusted so that the set values of the welding variables are reproduced accurately and consistently each time a weld is made. Maximum limits of fluctuation which can be tolerated are shown in Table II. These limits only apply when the recommended conditions (as given in Table I) are being observed. If the conditions are different, the limits of fluctuation which can be tolerated before there is a deterioration in weld quality may be much smaller.

The most important variable is the welding current, and particular care should be taken to maintain accurately the values selected. The most likely sources of variation in welding current are mains-voltage fluctuations and the insertion of different masses of magnetic material (the work itself) in the throat of the machine and/or bad

TABLE II—*Effects of Changes in Welding Variables at Recommended Conditions*

Factor	Limits of variation of recommended value ± per cent	Strength values
Current	6.0	Individual strength within ± 10 per cent of average
Time	8.5	
Load	10.0	

contacts in the secondary circuit. The mains-voltage fluctuations may arise in the factory system and some improvement could be obtained by good planning of the factory load. Constant current control units are available which largely overcome both the first two difficulties, and regular maintenance of the machine will ensure that bad secondary circuit conditions do not arise. Variations in weld time have an important effect though rather less than variations in welding current. The large variations are more likely to occur at short weld times unless fully synchronous timers are used. Variation in actual electrode load is the least important of the three major variables, though if the load is reduced, trouble may be experienced due, particularly, to the expulsion of molten metal during welding.

All these variations can occur together during operation of a machine. The most important individual factor is the welding current, which should be as consistent as possible if badly-fitting components have already reduced the effective pressure of the electrode on the weld. It should be noted that all these variations can occur together, though in general they will not all move simultaneously in the direction which reduces weld strength. With modern automatic controls, the variations in current, time and electrode load which are encountered together should be small enough for the weld strengths to be maintained within ± 10 per cent of their average values.

Weld Strengths

The weld shear strengths quoted in Table I and Fig. 2 are the failing loads obtainable in single spot specimens of low-carbon steel sheet. They are only given as a guide to what may be expected, and may not be exactly reproducible due to slight differences in steel composition or condition. The specimen size can also affect the failing load obtained, a narrower specimen giving lower strengths the sizes which were used in obtaining the values quoted in Table I are as follows :—

24 s.w.g. (0.559 mm.) ; ¾ in. (19 mm.) wide ;

20 to 12 s.w.g. (0.914 to 2.64 mm.) inclusive : 1½ in. (37.5 mm. wide ;

TABLE III—*Change in recommended conditions necessary when welding at pitches of 3d and less (d = electrode tip diameter) for two equal thicknesses of material*

Pitch of welds	24 to 14 s.w.g. (0.559 mm. to 2 mm.). Increase in welding current required to maintain strenth (per cent)	⅛ in. (3.18 mm.) Increase in weld time to maintain strength (per cent)
3*d*	3	25
2*d*	9	40†
1½*d*	14	Not suitable
1d*	20	Not suitable
½*	30	Not suitable

* At these pitches the percentage increase in secondary current depends to a great extent on the speed of welding. Where this is 60 welds per min. or more it may be found that the resultant build up of heat from previous welds is sufficient to allow the use of values of secondary current equal to or lower than those recommended for single welds in Table I.

† Condition not recommended.

⅛ in. (3.18 mm.) : 2 in. (50 mm.) wide.

A further influence on strength measured is the straining rate during testing ; the greater the rate, the higher the strength which may be measured. These values are based on a straining rate of 0.15 in. (3.8 mm.) per min.

Weld Pitch

The recommended minimum weld pitch is three times the weld diameter (*see* Table I) and even at this pitch some slight increase in energy supplied may be necessary to ensure that the second and subsequent welds have a strength equal to that of the first weld. This is because some loss of current occurs due to shunting through welds which have already been made. The appropriate corrections for welding current or weld time are given in Table III. It should be noted that compensation for current shunting can be made by increasing current when welding material up to, and including 14 s.w.g. (2 mm.), but for material ⅛ in. (3.18 mm.) thick compensation by increasing current is not a satisfactory method since troubles arise due to expulsion of metal from the weld. In this case, the effect of previous welds must be counteracted by an increase in weld time. Weld pitch may be reduced in the thinner materials to a point where welds are overlapping, and when this is the case the necessary increase in secondary current depends, to a large extent, on the speed of welding. Where high welding speeds are used, of the order of 60 welds per min. or more, it may be that the resultant build up of heat from previous welds is sufficient to allow the use of the originally recommended secondary current, or possibly even a

lower current than recommended for single welds. For $\frac{1}{8}$-in. (3.18-mm.) thick material, weld pitches of less than 3d. are not recommended.

Edge Distance

This is the distance from the centre of the weld to the nearest edge of the work piece. It is recommended for normal work that this distance is not less than $1d$ where d = electrode tip diameter. The use of an edge distance less than this value may produce one or both of the following effects :

(i) Metal expulsion due to the proximity of the sheet edge ;

(ii) Reduced weld strength due either to a poor quality weld from which metal expulsion has occurred, or to the proximity of the sheet edge, or both.

Using the normal type of single weld test specimens previously described, no appreciable decrease in failing load is obtained with edge distance down to $1\frac{1}{2}\ d$. When the edge distance is reduced below this, a decrease in failing load is observed and expulsion of metal from the weld zone readily occurs. This adversely affects weld consistency, and gives a poor appearance. The reductions in failing load which may be expected are given in Table IV, though it must be noted that these are only examples ; the actual reductions obtained in any particular instance will depend on the welding technique used, and condition of material and material surface.

TABLE IV—*Reduction of failing load when welding at an edge distance of less than 2d for welds made in accordance with the recommended conditions. (Two equal thicknesses from 24 s.w.g. to $\frac{1}{8}$ in. (0.559 to 3.18 mm. steel sheet)*

Edge distance	Average reduction in failing load per cent	Degree to which expulsion of metal occurs
$2d$	0	Nil
$1\frac{1}{2}d$	1.5	Nil
$1d$	6	Slight
$\frac{1}{2}d$	25	Moderate

Spot Welding Two Components of Different Thicknesses

Spot-welded joints may be made in most combinations of sheet thicknesses in the range of 24 s.w.g. (0.559 mm.) to $\frac{1}{8}$ in. (3.18 mm.) although in extreme cases difficulties may be encountered and the settings and results given in this document may not apply. When a joint between dissimilar thicknesses is made, the electrode tip sizes used should be those appropriate to the thickness of the sheet with which the electrode will be in contact and welding conditions similar to those recommended for welding two thicknesses of the thinner sheet are generally suitable.

Spot Welding Together Three or More Thicknesses of Sheet

More than two equal thicknesses of sheet may be spot welded together, using the settings recommended in Table I for two thicknesses. While similar welding currents are required, the use of a higher transformer tapping will generally be necessary to obtain those currents in order to counteract the increased resistance of the work pieces. When spot welding together more than two equal thicknesses of sheet, a single nugget is obtained passing continuously through the inner sheet or sheets and penetrating into the outer sheets for a distance rather less than that obtained when welding two sheets. The consolidation of the weld nugget joining three or more sheets is not as good as that obtained in a weld nugget joining two only, owing to the fact that mechanical forging of the weld is much less in the former case. This may give rise to porosity, and allow the formation of shrinkage cracks in the weld nugget. Some improvement can be obtained by increasing the load above that given in Table I, though this will probably necessitate a corresponding increase in welding current.

The Effect of Using One Electrode Tip of Truncated Cone Shape With the Other Electrode Flat

Where minimum indentation is required on one surface of the joint, it is recommended that the size of the electrode tip used on this face should be larger than that normally used, but should preferably be kept to the minimum which will give the desired absence of surface marking. If the large electrode is against a thin sheet for welding to a thicker one, the welding conditions are more critical and the recommendations of Table I may not apply. With equal thicknesses, the use of a flat electrode requires no change in the recommended welding conditions though the weld consistency may deteriorate due to indenting of the larger electrode. The use of a large radius (10 in.—25 cm.) on the large electrode tip facilitates the production of welds of consistent quality, while still keeping surface marking to a minimum.

Appendix

The foregoing recommendations are based on tests and wide industrial experience in the use of low-carbon mild steel. The majority of the test material was of a type widely used in the production of light engineering products, *i.e.*, of a deep-drawing-quality steel. The carbon content of such material will generally not exceed 0.1 per cent, and may be as low as 0.6 per cent. The maximum

(*Continued in page* 670)

Quality Control of Welded Fabrication

By S. ROWDEN, A.I.M., A.M.I.W.*

THE atomic, chemical, petroleum and other branches of industry continue to absorb greater volumes of fabricated components. These may include pressure vessels, heat exchangers, storage tanks, pipelines or a miscellany of items. Since the volume of weld metal in these units may be quite considerable, some form of guarantee is required by the users. It thus becomes the fabricators' responsibility to ensure the final item is of the required standard, although this often becomes a joint responsibility with an independent inspectorate.

In order to weld any vessel, and correlate its quality with service life, a code of manufacture is frequently imposed on the fabricator. This thus becomes the working guide during, and after, the end product is finalized. Weld quality is thus related to this code of manufacture, and for economical reasons, bears relationship to the subsequent duties. Thus either by destructive or non-destructive tests weld quality is assessed according to the fabrication specification. Acceptance or rejection in part or whole of the weld seams is entirely a function of this latter code.

From the inception of the contract close control is maintained over incoming materials, and each stage of manufacture is a venue for surveillance. Broadly speaking the resultant programme may be subdivided into :—

(i) Materials ;
(ii) Manufacture and workmanship ;
(iii) Inspection and tests.

Design aspects are of course a pre-determined quantity but occasions do arise during fabrication when some modifications become necessary. In this event liaison between the respective parties results in an amicable agreement and the fabricator proceeds in his project.

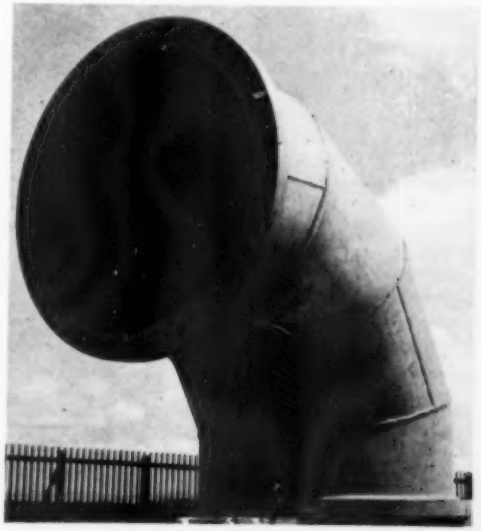
Materials

All materials used for a said contract must conform with the appropriate material specification. Where this is non-existent then choice is usually a matter of discretion, and if no code exists the unit will almost certainly be used for non-onerous duties. The manufacturer would then be justified in using a commercial grade of material without recourse to the more expensive metals. Notwithstanding ultimate service duty, however, the inspecting company may still insist on the material being tested guaranteeing that it would meet the service requirements quoted by their client. Committed responsibilities in testing would depend upon the material in question, often the principal tests being a determination of the mechanical properties and chemical analysis.

Frequently the steel manufacturer issues mill certificates covering all materials in question. It suffices therefore for the fabricator to submit these for approval.

There is a present trend today in clients' code requirements to call for ultrasonic examination prior to plate handling operations. Generally only plate edges which ultimately form the weld joint are examined but it is not uncommon to carry out

Fig. 1.—Ducting fabricated in low-alloy steel for use in the chemical industries



* Ashmore, Benson, Pease and Co., Ltd.

a full scanning of the plate or section to detect any possible imperfections. The value of this mode of examination is well justified, especially when dealing with thick plates.

Manufacture and Workmanship

Having established that the material is satisfactory, shaping by rolling, pressing or forging may follow. Whether this is done cold or hot depends upon machines available, thickness and type of material. Aged practices of forming operations, often an art rather than a science, are rather out of place in modern engineering. This is particularly true in hot working metals when strict temperature control is of paramount importance. Furthermore, it may become necessary to analyze the furnace atmosphere in the heat-treatment of special alloys. Nickel alloys are exemplary in this direction.

The unit having been temporarily assembled and held in position by tack welds, a preliminary examination of joint set is afforded. From a welding viewpoint this stage can be most informative despite the absence of the weld joint. Truth of this statement is appreciated when weld defects are assessed quantitatively. Mislignment, lack of root fusion, excessive penetration, and even weld cracking can often be attributed to a poor joint design. In pipework, time spent in approving individual weld joint set up often shows adequate rewards during radiographic examination of the finished welds. If the vessel or item is being constructed to general British codes of manufacture then production weld tests are invariably carried out during the process of fabrication. However, the American Society of Mechanical Engineers and American Petroleum Institute standards function from rather a different viewpoint. It is the practice under these codes to approve the welding procedure and welders prior to actual fabrication of the vessel or other such unit. Qualification and procedure tests are designed to show, with preferentially the minimum number of tests, the capabilities of the welder. In some instances these tests may qualify him for a range of materials and thicknesses, and on occasions, welding position. Weld qualification tests should not be regarded as a luxury or conversely, deterimental to production. On the contrary, they should be accepted as being complementary to the more accepted tests, *e.g.*, hydrostatic and X-ray ; as such, they serve as a guide to satisfactory service performance.

All of the aforesaid remarks refer particularly to procedure and qualification tests, generally based on the A.S.M.E. or A.P.I. codes of practice. Production weld-test plates, based upon Lloyds Register of Shipping, U.K.A.E.A. and B.S. 1500 standards, are rather different, though nonetheless important, such tests, in the form of plates attached to the main seams, divorce weld test plates into two categories.

Concern in the A.S.M.E. and A.P.I. specifications is in establishing the procedure and the welders before commencing work on the actual contract. Non-destructive tests will almost certainly supplement these tests during the fabrication stage. Taking a rather divergent path, the production test-plate method is based upon checking the weld quality at some stage of fabrication. The obvious choice is the main weld seam and normally a plate is attached to each end of the seam, becoming a continuation of it during the welding traverse.

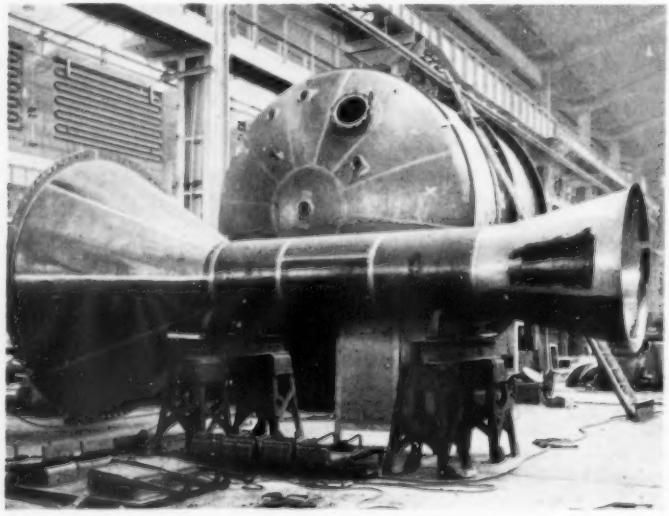


Fig. 2.—Part of a pure-nickel Krystaliser constructed to Lloyds Class II *requirements*

On completion of welding of this seam they would be removed and subjected to destructive tests.

Irrespective of the code of manufacture, detailed test-pieces are designed to yield definite knowledge of the mechanical properties of the weld metal. Objective achievement for the independent specimens may be clarified as follows. Ultimate stress, yield stress, ductility, notch toughness and quantitative weld assessment are all values of paramount importance. It often follows that where a vessel is to be used in a sub-zero temperature environment, special low-temperature notch toughness tests will be called for. The purpose is quite clear here and due cognizance must be taken in the loss of toughness of metals with fall in temperature. Some guidance can often be found in the relevant code as to the minimum acceptable values at the temperature of operation.

With a pre-determined knowledge of the mechanical properties of the weld metal known, it then becomes necessary to supplement them with non-destructive tests during fabrication. These latter tests may embrace radiographic control, crack detention techniques, ultrasonic testing or even specialized vacuum testing. Of necessity such tests are limited to code requirements and the stipulations therein. It is not uncommon, however, to observe in many specifications a clause permitting the degree of radiography to be raised at the discretion of the inspector.

Perhaps the most significant feature of non-destructive tests, particularly radiography is not the extent of them but the permissible tolerances in defects. These may be clearly defined and if so, present no great problem even to the most exacting weld specification. Unfortunately, some codes of practice are less explicit and ambiguity on interpretation may arise. Nevertheless, final decision is invariably left to the resident inspector. The inherent dangers of weld defects are largely related to their shape and size. Weld cracking is almost universally intolerable while some relaxation, with respect to slag, lack of penetration and porosity, is permitted. Recent trends in the field of non-destructive testing appear to confirm the increasing popularity of ultrasonic inspection. Sensitivity-wise, it represents an accurate evaluation of weld seams although the prejudice against greater usage definitely exists. The greatest single factors may well be an absence of permanent record and the obvious practical limitation on complex structures.

Inspection and Tests

No clear demarcation limit exist between stages of fabrication with respect to actual tests unless they be specific items such as weld tests. Material control, weld procedure and production test plates, and radiographic requirements have all been dealt with previously and it only remains to analyze the ultimate stages.

Fig. 3.—Monel fabricated pipe section designed for handling brine solutions

Often the penultimate stage is some form of stress-relief treatment, which may be mandatory depending on the code specification. Heat treatment of vessels should be carried out after all welded fittings and connexions have been attached to the vessel. Rectification of weld defects is normally restricted prior to stress relief.

Where possible the whole fabricated assembly should be relieved as a whole in a furnace. Complicated structures, or inconvenient lengths, may be stress relieved *in situ* by numerous means. Induction and resistance heating methods are becoming more popular in this direction, in some instances being the only practical way of achieving such an aim, *e.g.*, site pipelines. A decision to stress relieve may be functional of specification requirements but normally is restricted to high-duty pressure vessels, components made of low-alloy steels, uncommonly thick vessels, say greater than $1\frac{1}{2}$ in., or vessels intended for low-temperature service. An additional class warranting mention is that of items to be employed in duties whereby stress corrosion may occur. If this is the only consideration, however, it is doubtful if stress relief

(*Continued in page* 670)

Quality Control of Welded Fabrication

(*Continued from page* 669)

is really necessary. Certainly in the case of austenitic stainless steel it is accepted that the degree of stress relief rarely exceeds 90 per cent efficiency, and either the remaining stress, or those induced by the cooling of material with a high coefficient of thermal expansion, are sufficient to cause stress-corrosion cracking.

Selection of the stress-relieving temperature is related to the metallurgy of the steel, time at temperature being a function of section thickness. Normally mild and low-alloy steels are heat treated at 600 to 650° C., and the austenitic stainless-steel varieties at 850 to 875° C. Fairly recent developments of the 5 per cent chromium-1 per cent molybdenum steels have justified raising the 650° C. to something between 700 and 750° C. B.S. 1500—Fusion Welded Pressure Vessels—cites a controlled heat input of 200° C. per hour up to the stress-relieving temperature, and holding for one hour per inch of thickness. A stipulated temperature fall is also required, 250° C. per hour, but this is quite difficult to produce as a determined value and for most industrial furnaces the cooling rates are sufficiently low to be acceptable. In so far as mild and low-alloy steels are concerned a protracted cooling rate is hardly detrimental but it is possible to envisage circumstances involving high-alloy stainless materials when there could develop attendant difficulties. Such problems would manifest themselves as structural changes within the steel and could give rise to problems. For this reason close temperature control throughout the full heating cycle is considered to be most important.

Ultimate inspection is based upon pressure testing and the germane operations. Design factors usually govern what the test pressure will be and the test is normally witnessed in the presence of the inspecting authority. The type of pressure test is dependent upon a number of variables and may be a standard or proof hydraulic, pneumatic or even vacuum. Hydraulic pressures are normally related to the safe working pressure of the vessel and over a given time period. This is the time needed to examine all weld seams and joints, or for a stated given period, whichever is longest.

Jacketed, multiple or coated vessels usually require some modification of pressure testing. Where the design is complex, or for reasons known exclusively to the plant user, it may become necessary to conduct the pressure test with gas in lieu of water. As in hydraulic testing, the pressure value is related to safe working values of the fabricated component. Invariably the selected pressure is quoted so as to be not greater than the design pressure.

At the final approval stage the mundane quotidian procedures arise. Dimensional checking, branch and scantling measurements and overall quality of workmanship is made despite the repeated surveyance which will have been maintained throughout the contract. The paucity of rejected fabricated items bears immeasurable value to the relationship between external inspectorates and fabricators. Perhaps the greatest danger to a fabricator is to adopt a perfunctory attitude to a contract. It is usually a sound policy to treat each job on its merits and to ameliorate ideas, energies and skill for each successive item.

Spot Welding Low-carbon Steel

(*Continued from page* 666)

permissible carbon content will increase with gauge thickness, as mentioned earlier, and if the carbon content exceeds the appropriate value, particularly if it is associated with high manganese, or if the steel contains appreciable percentages of the residual elements, the rapid rate of cooling of the weld can give rise to excessive hardness, or even cracking, in the weld or heat affected zone. The spot welding of such hardenable materials require special techniques which are outside the scope of these recommendations. An example of material which cannot be successfully welded by the simple method outlined in this report is steel to Air Ministry specification 3S3, where the carbon content is greater than 0.2 per cent.

The surface of material which is to be welded should be clean and free from loose or rolled-in scale, dirt, paint and grease, otherwise splashing will occur. When ordering material, the customer should notify the steel manufacturers that the steel is required for spot welding, so that these requirements can be met. It is possible to spot weld mild steel which has its surface protected by certain thin electrolytic deposits or metallic paint primers but special welding conditions may be required and electrode life will be reduced due to pick-up of the coatings.

References

(1) (*a*) Hipperson, A. J., "A mains operated valve voltmeter for the measurement of secondary current in resistance welding machines," *Welding Research*, 1948, June, **2** (3).

(*b*) Dixon, H. E., Roberts, J. E., and Roberts, T. M., "The measurement of spot welding machine variables." Report LR/9A, *Welding Research*, 1953, February, **7** (1).

(2) "Instruments for the measurement of the main variables in resistance welding," first interim progress report of FR.5 Committee, *Welding Research*, 1947, December, **1**, (5).

SHEET-METAL STAMPING AND PRESSING

Recent Research in the U.S.S.R.

Reported by W. G. CASS

IN the section on " Working Metals by Pressure " of *Vestnik Mashin* (1958, **38** (10), pp. 47-58) is a series of articles mostly on sheet-metal working.

The first, by *Prof. A. D. Tomlenov*, is a brief review of the theory of the hydrostatic testing of sheet metal through bulging. Reference is made to earlier work by *Sandler et al* (Russ. *Zavods. lab.* (12), 1951), on a device for testing thin sheet metal under duo-axial tension ; by *Jevons*, on metallurgy of deep drawing, 1940 ; and *Y. Yamada*, on the theory of formability testing of sheet metals (Proc. of 2nd Jap. Nat. Congress for Appl. Mech. 1952) ; also to the author's own contribution on the plastic stressed state and stability in drawing complex parts, in a symposium on " Problems in Working Metals by Pressure," pub. by Acad. Sci. USSR, 1958. The only other reference is to R. Hill, on a theory of the plastic bulging of a metal diaphragm by lateral pressure, in *Phil. Mag.* 1950, **41,** pp. 1133-1144.

The theory of hydrostatic testing developed in the present article permits calculation from experimental data of the basic characteristics of sheet metal and the construction of a diagram of true stresses. A diagram shows a section of a deformed membrane corresponding to maximum pressure of a liquid p. Relevant equations (for membrane surface) have the form $z = z(y)$, a function which, as *Hill* has shown, is determined by the properties of the deformed sheet metal. It is here shown as a power series, on the basis of which 27 equations are developed, where (27) gives the value of n representing the capacity of a metal to increase its strength, one of the most important characteristics that determine formability.

The second article deals with the stamping and forming qualities of sheet steel, by *L. A. Rubenkova*, reporting work in the metal-treating lab. of the Inst. of Machine Theory and Design, Acad. Sci. USSR., with special reference to drawing processes. Investigation has shown that a decisive factor in the behaviour of a metal is the stressed condition arising through stamping, etc. There are three groups of tests for this : (*a*) mono-axial tension; (*b*) bi-axial tension, as in hydraulic extrusion or pressing on Erichsen and other apparatus, and (*c*) the complex stressed state, as in deep drawing which also includes compression. Only the two first are discussed here.

In (*a*) the most important values are those of stress σ_k and deformation ψ_k under maximum load, corresponding to the moment of transition from stable to unstable state :—

$$\psi_k = \frac{F_o - F}{F} \cdot 100 \text{ per cent}$$

where F_o is initial cross section area and F is actual ditto. The tests described show that for good (bad) formability σ_k = 42.3-49.5 (33-38.8) ψ_k = 20.2-24.3 (10-18.5). Additional tests were made to determine optimum shrinkage or reduction, with rolled strip, with the following results :—

Reduction (per cent)	0	0.5	1	2
σ_k	39.3	39.8	40.82	41.07
ψ_k	14.75	15.45	16.57	16.7

It was confirmed also that the diagram of true stresses is a better guide to the stamping qualities of sheet metal intended for finished car components than the usual diagram of deformation forces.

Characteristics are tabulated for two pieces of steel strip differing in chemical composition (though it would seem only slightly), including results of Erichsen, Olsen, and hydraulic drawing tests, also yield strength (σ_t), etc. The profile of the drawn testpiece was determined by point co-ordinates and calculated from the Tomlenov formula (*see* No. 1 article of this series, ref. to symposium on working metals by pressure). Deformation was measured in relation to increase in load or liquid pressure (P), and a graph constructed for $P = f(h)$ and $\tau_o = f(\gamma_o)$ where h is depth of drawing, τ_o is octahedral stress, and γ_o is end octahedral shear (shift). Formulae are given for calculating these two latter. Values for bad and good formability are :—

	P_{max}	h_{max}	$\tau_{o\,max}$	$\gamma_{o\,max}$
Bad	65	59	2,450	0.75
Good ..	65	73	3,100	1.05

The octahedral stresses and their relations, including those with c (not defined) and n, are further discussed with relevant equations—(5) to (10) in original—and it is stated that the values c and n characterize the capacity or quality of the metal for strengthening (*see* No. 1 article herein).

It is shown that, with bi-axial drawing, the

possible maximum critical deformation is much greater than with simple mono-axial drawing. This was confirmed by further experiment, briefly described, and results tabulated. Considerably higher values of deformation correspond to the moment of stability loss than in the case of mono-axial drawing, so that, in regard to drawing quality it is better to judge from the test results of bi-axial drawing. Some experiments with automobile radiator parts indicated that the thinning (reduction) of metal in some places reaches 50 per cent.

It is pointed out that in the liquid test the form and disposition of cracks may vary appreciably. That is to say, machining cracks occurring arbitrarily over the surface arise from surface defects and should not be taken into account. C-shaped cracks occurring at the drawing point (tip) are due to accidental presence of air. The usual form of cracks is that of a slit. Some other factors are briefly noted including more especially the question of friction, for which some results are graphed from drawing tests with the Olsen machine and a new apparatus known as IMASh. As might be expected, with increasing load the effect of friction is more marked, and proper lubrication, therefore, is obviously essential. References include: *N. A. Kuklo* (*Zavods. lab.* (1) 1957), on tests with the Erichsen machine; *Tomlenov* (*loc. cit.*), and *Sachs and Lubahn* (*Trans. ASME*, May, 1946) on failure of ductile metals under tension.

Improving production methods of sheet steel components, by P. G. Kovtun, is the subject of the third paper. With the usual methods wrinkles or folds often appear and have to be removed. The author and colleagues have introduced improved methods of drawing and calibration in the stamps or presses. To avoid wrinkles the components are made with flanges and have reduced diametral sizes. To ensure necessary width of flange the parts must be understamped by about 15 to 20 per cent. Drawing can now be done with a small coeff. of draw, whereby the dimensions of the component under calibration can be obtained with fewer operations (*ref.* 1). Moreover, the presence of a flange permits good stretching or cover of the metal by the calibrating (grooving) piston. For centring the part in the calibrating die it is necessary to curve the edge of the drawing die with a larger, and the calibrating dies with a smaller, radius (as much as possible). Curvature radius of former should be (30-40) s_t and of the other (6-8) s_t, where s_t is thickness of the steel sheet.

Calibration is done as follows (Fig. 1): The component after drawing is placed in the die 1 and centred with the aid of a curve. The holder 2 presses the flange of the part on to the surface

Fig. 1

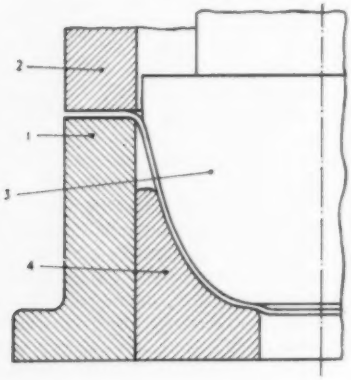


Fig. 2

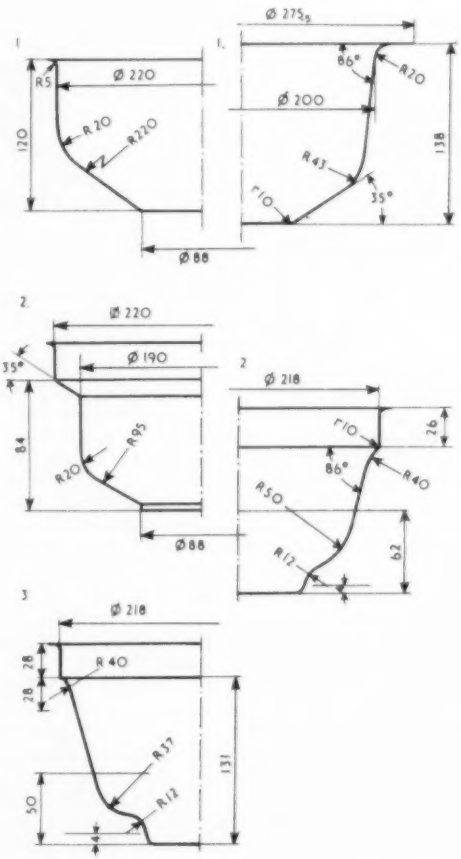
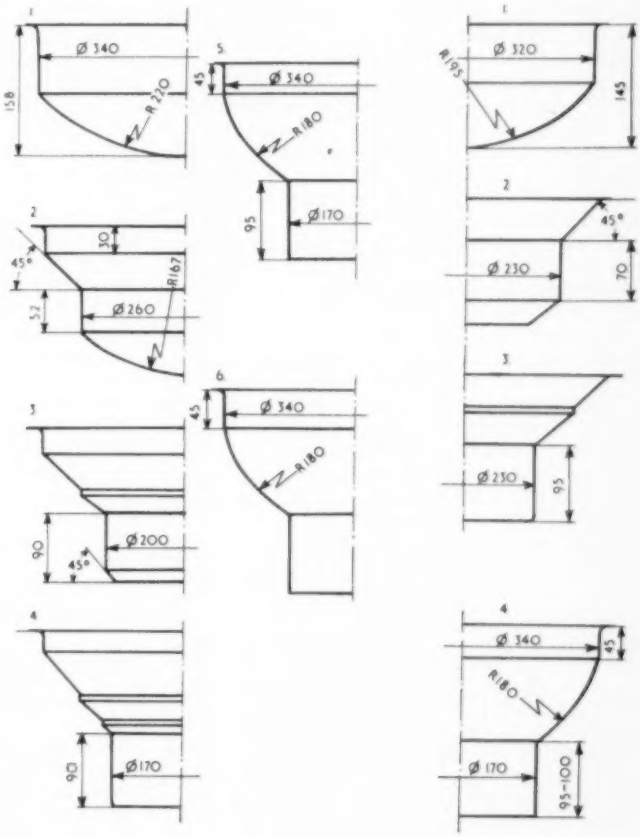


Fig. 3



of the die with a force sufficient to prevent formation of the folds below it and when tightening the metal in the die. With movement of plunger 3 and stretching of metal the flange begins to form at the upper part, while the lower part is shaped by thrust block 4 which, when necessary, can play the part also of ejector. Working surface of plunger is 15 to 20 per cent larger than that of the drawn part of workpiece so that, in calibrating, there is all-round extension of the walls without folding or wrinkling, and such as may have occurred is smoothed out; so that rolling, etc., with possible cracking and other troubles are eliminated.

Using the above method the workpieces need only one drawing and one calibration, so that they are plastic (ductile) enough, and annealing before edge-rolling and other operations are unnecessary. The whole process is much simplified and risk of damage reduced accordingly. Some examples are shown in Figs. 2 and 3, with the old method shown on the left and the new on the right :—

	Operations Old	New
Fig. 2, for workpiece A—		
D 370 mm. s_t 0.5 mm. ..	4	2
Fig. 3, for workpiece B—		
550 mm. 1 mm. ..	8	5

Drawing coefficients are reduced, namely to 0.54 for the first operation in the case of workpiece A (ref. to *V. P. Romanovskii's* book on cold stamping 1956, pub. Mashgiz).

The remainder of the article deals with inter-operational annealing to restore ductility that may have been lost in drawing. Pickling to remove oxide also has hitherto been necessary, though very undesirable. It can be avoided or the trouble much reduced by the annealing method herein described. This in brief means using flame or muffle furnaces and specified temperatures, with preliminary treatment of the parts in an 8 to 10 per cent solution of ammonium chloride. By proper annealing the need for pickling is obviated, wear on the dies, etc., and rejects are much reduced.

M. V. Rastegaev, with a lot of previous work to his credit in this field, discusses some problems in the hot working of heat-resistant alloys; more especially (1) recrystallization; (2) basic conditions ensuring high ductility both in heat-resistant alloys and in materials that are brittle under ordinary deformation conditions; (3) joint effect of structure and nature of stressed condition on ductility;

(4) developing new methods of deformation and testing them under works conditions. Several alloys of the EI class were studied.

In regard to the first and for establishing the correct thermo-mechanical regime for hot working it is necessary to have the space diagram of recrystallization of the second order, for which a method described here as " new " was given by the author in *Zavods. lab.* (3), 1940, in connexion with uniform deformation in upsetting. With this method it is possible to obtain at high temperature (800 to 1,350° C,), in one upsetting, a high degree of reduction of the cast alloy without damage. A diagram in original shows this spatial (steric) diagram, in the temperature range of 1,050 to 1,250° C. It was found that high ductility of brittle materials such as cast iron and some alloys (also marble) is ensured by uniform deformation and close (literally " all-round ") compression. Marble could be reduced by 78 per cent and cast iron by 58 per cent.

(Ref. to 1956 symposium on this subject by Acad. Sci. USSR). Steel rings were used for the purpose.

Several methods are discussed for the plastic deformation of brittle materials, including a study of the heat effects arising in non-uniform deformation and of the stressed condition. The methods included resistance heating of a tapered plate at the rate of 25,000 to 30,000°(?) per sec. in a stream of water ; indentation to determine micro-hardness after heating both by electric current and by deformation under impact load ; high temperature treatment of circular testpieces for impact tension (elongation). Some results are graphed showing that the ductility of difficultly deformable alloys, under high-temperature deformation and in the presence of tensile stresses, depends mainly on the form and character of the distribution of the second phase, not in the initial structure but in that formed by heating or otherwise at the moment of initial deformation.

Due to the heat effect, arising under high temperature non-uniform deformation, the second phase occurring in the alloy in the form of globules, in the regions of shear (or slip), passes into solid solution, whereby there is saturation of the adjacent voids and their subsequent melting. If with this there is also a stressed condition then rupture or breakdown is inevitable. This is exemplified from the microstructure (shown in orginal) of an IE alloy under test for impact tension (elongation) at 1,200° C, showing the transition from globules to solid solution.

Coming now to an experimental study of the mechanism of crack formation in forging and rolling, it was found that the cracks could be classified in accord with the two named forms of breakdown ; (*a*) intercrystalline, and (*b*) wedging out or tapering and shear or cleavage. These are discussed and illustrated. Finally, the ductility of an alloy under hot deformation is plotted against condition of structure forming at the moment of initial deformation, for (1) drawing, (2) open upsetting, and (3) rolling.

The general conclusion is reached that the problem of high temperature deformation of difficultly deformable alloys must be solved by the development of such a mechanical set-up as will permit a tri-axial compression with close approximation to uniform deformation. Such an arrangement is essential in order that, in the initial reductions, maximum recrystallization is secured in the whole of the deformed volume of metal, to eliminate all old grain boundaries, with coagulation of the second phase. To this end methods were also developed of conical recessing as explained in earlier work (Possibility of working under pressure in relation to uniform deformation—Symp. on Research on heat-resistant alloys, Pub. Acad. Sci. USSR, 1956). These methods have been tried under factory conditions and gave positive results. (Five refs. all under author's name.)

COMPLETE FINISHING SYSTEMS FROM ONE SOURCE

FOR the first time in this country, complete paint finishing systems, from metal pre-treatment to final stoving, can now be installed by a single organization, the Lysaght-DeVilbiss Division of John Lysaght's Bristol Works Ltd. This organization has been formed by linking the well-known engineering skill of John Lysaght's with the specialized experience of Aerograph-DeVilbiss in the design and manufacture of complete systems, thus combining resources of two factories. Previous co-operation between these two companies has already led to major contracts for finishing plant in the motor industry and in domestic appliance manufacture. Lysaght-DeVilbiss, backed by a country-wide sales force, has its sales organization at 47, Holborn Viaduct, London, E.C.1.

UTRECHT AUTUMN FAIR

OUT of a total of 1,083 exhibitors at the Utrecht Fair to be held from September 12 to 17, 48 will be from the U.K. Switzerland will have 35 exhibitors, France 31 and Western Germany 161. Altogether 23 countries will be represented.

TREATMENT OF WASTE ACID FROM PICKLE AND SCRUBBING LINES

Procedure Adopted at the Abbey Works of The Steel Company of Wales Ltd.

By M. SMALLWOOD, A.M.I.Mech.E.*

MUCH has been written on this subject, but in view of the more stringent attitude adopted by the River Boards and authorities regarding pollution it is of interest to read how one company solved the problem.

In 1948, just after The Steel Company of Wales was formed, an investigation was begun into disposal of acid waste from their Abbey Works pickle lines and scrubbing lines, using sulphuric acid and hydrochloric acid, respectively.

Acid-recovery plants were considered, both the evaporative type and refrigerative type, as well as neutralization, and also dumping waste acid at sea in specially constructed barges.

An acid-recovery plant was the obvious solution to the problem, as ferrous-sulphate monohydrate is produced as a saleable product which can be used for the production of sulphuric acid when mixed with pyrites and roasted. Neutralization, on the other hand, does not result in any saleable product.

After much thought it was felt that acid-recovery plants were not advanced enough, and, possibly, not reliable enough at that time for continuous large-scale recovery and that some form of neutralization would still be necessary. Acid recovery was, however, kept in mind for installation at a later date when the plants had improved and space was allotted on the site for such a plant.

Because Abbey Works was on the coast, dumping at sea was considered next, and various designs of self-propelled barges were made and prices obtained from shipbuilders. This method of disposal had finally to be ruled out, because, among other things, the Bristol Channel is notoriously rough and very large holding tanks would become necessary.

The remaining alternative method, by neutralization, was finally decided upon and many alkaline substances were examined with a view to efficiency and cheapness.

Tests were carried out, mixing samples of waste pickle liquor and wash water and neutralized with limestone passing a 30-mesh screen. After agitating the mixture for three hours and allowing one hour for settlement, about 60 per cent of the volume was clear enough to be returned into the works industrial water system; but this left a considerable volume to be dumped. Further tests were made with limestone which had passed a 200 sieve, but here again a large volume of residual sludge had to be dumped and the time for the whole reaction was considerable, necessitating a large plant.

At about this time it was learned that a trade waste—wholely alkaline—was being dumped at Barry, about 20 miles away. When tests were made on this waste it was found to be suitable for neutralizing the acids, and arrangements were made to obtain this waste and transport it by road tanker in 3,000-gallon loads to Abbey Works.

It was obvious that when acid-recovery plants improved and a market made for the product, it would only be economical to treat the waste pickle liquor which normally contains between 5 per cent and 12 per cent H_2SO_4 and the acidic water from the wash tanks would still have to be neutralized as it contains a minute portion of acid and consists of drag-out from the last acid tank. Consequently, it was decided that the neutralizing should be split into two parts, one being for the strong acid and the other for the wash water, the purified wash water being returned to the works industrial water system.

From one continuous pickle line producing 10,000 tons of pickled strip per week, some 1,200 gallons of waste pickle liquor per hour and 12,000 gallons of wash water per hour are available for neutralization. Assuming the waste pickle liquor contains 5 per cent H_2SO_4 and 20 per cent $FeSO_4$ W/W with a specific gravity of 1.25 and the rinse water to contain 0.5 per cent H_2SO_4 and 0.1 per cent $FeSO_4$ W/W with a specific gravity of approximately

*Steel Co. of Wales, Ltd.

1, the following quantities of neutralizing agent would be required:—

Waste Pickle Liquor:

1,200 gal. per hr. = 15,000 lb. containing 750 lb. H_2SO_4 and 3,000 lb. $FeSO_4$ and 11,250 lb. water.

Theoretical lime $Ca(OH)_2$ required.

(*a*)	H_2SO_4	+	$Ca(OH)_2$	=	$CaSO_4$	+	$2H_2O$
Using A.wt.	98	+	74	=	136	+	36
	1.34	+	1.0	=	1.84	+	0.5
Actual wt.	750	+	560	=	1,030	+	280
(*b*)	$FeSO_4$	+	$Ca(OH)_2$	=	$Fe(OH)_2$	+	$CaSO_4$
Using A.W.	152	+	74	=	90	+	136
	2.05	+	1.0	=	1.21	+	1.84
Actual wt.	3,000	+	1,460	=	1,760	+	2,700

The trade waste from Barry contains 20 per cent lime in the form of a slurry, and using this slurry, the total amount required to complete the reactions (*a*) and (*b*) above is 10,100 lb.

This would give a sludge containing the following:—

	$Fe(OH)_2$	$CaSO_4$	H_2O
From (*a*)	—	1,030 lb.	280 lb.
,, (*b*)	1,760 lb.	2,700 lb.	—
,, lime slurry	—	—	8,080 lb.
,, original liquor	—	—	11,250 lb.
Totals	1,760 lb.	3,730 lb.	19,610 lb.

Therefore total weight of sludge=25,100 per hour. Assuming S.G. of 1.24, volume of sludge per hour =2,030 gal.

No allowance has been made in the above calculations for the small amount of excess trade waste which would be added in practice. This would be of the order of 5 per cent.

With regard to the wash water: this gives the following:—

W/W S.G.I.O.

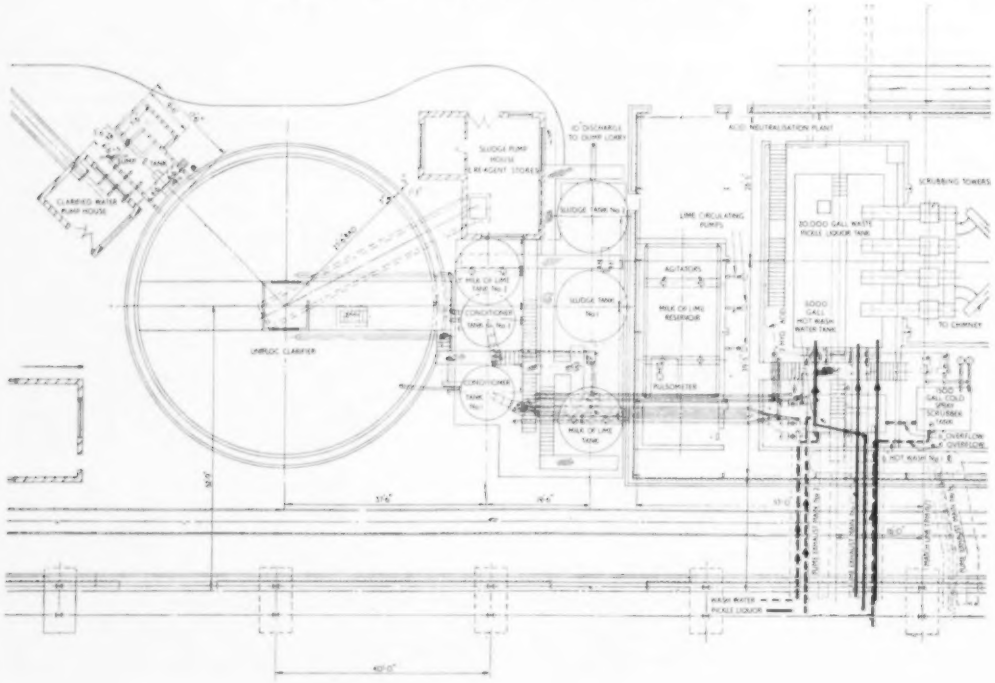
	H_2SO_4	=	60 lb.		Water	=	11,982 lb.
	$FeSO_4$	=	120 lb.				
(*a*)	H_2SO_4	+	$Ca(OH)_2$	=	$CaSO_4$	+	$2H_2O$
	60	+	45	=	83	+	22
(*b*)	$FsSO_4$	+	$Ca(OH)_2$	=	$Fe(OH)_2$	+	$CaSO_4$
	120	+	59	=	70	+	109

Using 20 per cent lime slurry, the amount of slurry required to complete reactions (*a*) and (*b*) is 520 lb. per hour.

Products	$Fe(OH)_2$	$CaSO_4$	H_2O
From (*a*)	—	83 lb.	22 lb.
,, (*b*)	70 lb.	109 lb.	—
,, slurry	—	—	416 lb.
,, original liquor	—	—	119,820 lb.
Totals	70 lb.	192 lb.	120,258 lb.

The water from the cold spray tank and the hot rinse tank on the pickle lines gravitates to a 5,000-gallon hot rinse tank in the neutralizing plant. The water is then pumped from this tank to a launder leading to a conditioner tank, and lime slurry from the milk-of-lime working tank is also

Fig. 1.—Neutralizing plant for Nos. 1 and 2 pickle lines



fed into this launder where it mixes with the wash water and falls into the conditioner tank where it is kept agitated by means of paddles. The water with its lime then flows through 8-in. and 10-in. pipes to the centre of a 75-ft. diameter Unifloc clarifier where a reagent is added, and the resulting sludge which settles at the bottom of the clarifier is pumped out by means of a diaphragm pump to the final sludge tank; the sludge is then taken away by tanker lorry for dumping. The water from the clarifier then flows to a sump from which it is pumped to a tower, from whence it gravitates to sea; or it can be put into the industrial works water supply, as mentioned previously, in times of shortage. However, without further treatment it could not be used in the works all the year round due to the gradual build-up of $CaSO_4$ in the system.

Fig. 1 shows the neutralizing plant for Nos. 1 and 2 pickle lines. It will be seen that the waste acid from the pickle tanks flows into a waste pickle effluent tank, from whence it is pumped to the launder between the milk-of-lime working tank and the final sludge tank. The milk-of-lime (lime slurry) is stored in a concrete tank in the floor of the neutralizing plant and is pumped from here to an elevated milk-of-lime working tank. The lime slurry flows from this tank into the launder and mixes with the waste pickle liquor, both of which then gravitate into the final sludge tank which is kept agitated the whole time by means of paddles.

Fume from the waste pickle liquor tank is collected in four ducts; the fume then passing to scrubbing towers filled with Raschig rings which are wetted by means of water sprays. The washed fume then passes to a 100-ft. high rubber-lined steel chimney.

In 1957, after further examination of recovery plants, a decision to purchase a plant was made and a further study of three types was carried out, and, eventually, a plant put forward by Nordac Ltd., (now a member of the Woodhall-Duckham group) was decided upon.

As three pickle lines are operating now and each has a separate maintenance period, it was decided that the recovery plant should be built in three separate units; one unit to work with one pickle line, but with the pipework so interconnected that any acid-recovery unit could be used with any pickle line. This would normally mean that an acid-recovery unit could go down for maintenance with its respective pickle line.

Fig. 2 shows one unit of the acid-recovery plant and indicates the flows through the pre-evaporator to the main evaporator, and then to the cooler separator, and finally to the centrifuge.

The pre-evaporator has nominal dimensions of 15 ft. × 8 ft. × 12 ft. 6 in., the main evaporator

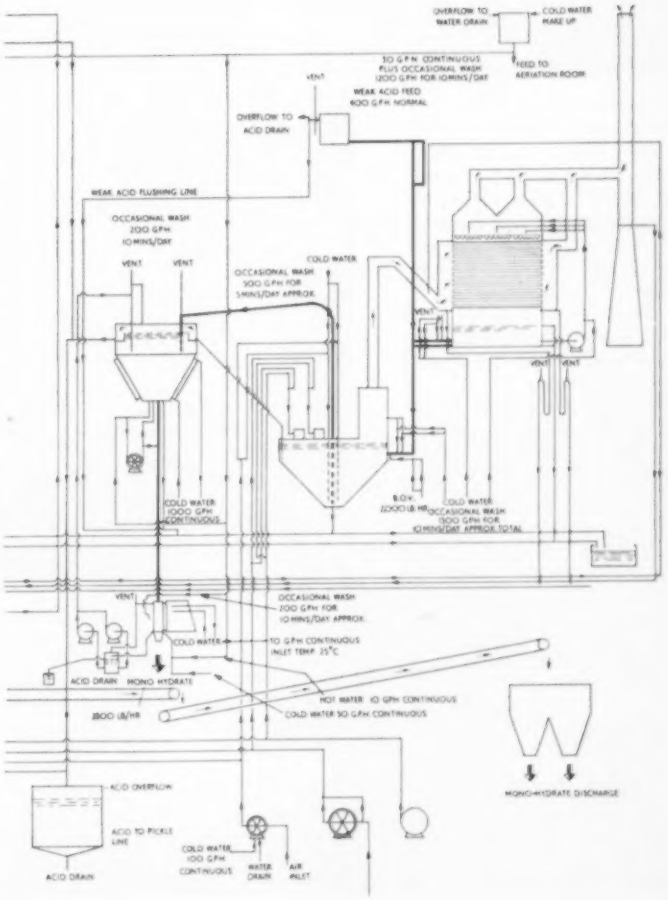

OVERFLOW TO WATER DRAIN
COLD WATER MAKE UP
FEED TO AERATION ROOM
VENT
WEAK ACID FEED 600 G.P.H. NORMAL
OVERFLOW TO ACID DRAIN
WEAK ACID FLUSHING LINE
OCCASIONAL WASH 1000 G.P.H. 10 MINS/DAY
COLD WATER
OCCASIONAL WASH 500 G.P.H. FOR 5 MINS/DAY APPROX.
COLD WATER 1000 G.P.H. CONTINUOUS
B.O.K.
OCCASIONAL WASH 500 G.P.H. FOR 10 MINS/DAY APPROX. TOTAL
OCCASIONAL WASH 1000 G.P.H. FOR 10 MINS/DAY APPROX.
TO G.P.H. CONTINUOUS INLET TEMP. 25°C
ACID DRAIN MONO HYDRATE
HOT WATER 10 G.P.H. CONTINUOUS
COLD WATER 30 G.P.H. CONTINUOUS
MONO-HYDRATE DISCHARGE
ACID OVERFLOW
ACID TO PICKLE LINE
COLD WATER 1000 G.P.H. CONTINUOUS
WATER DRAIN
AIR INLET
ACID DRAIN

Fig. 2.—One unit of acid-recovery plant

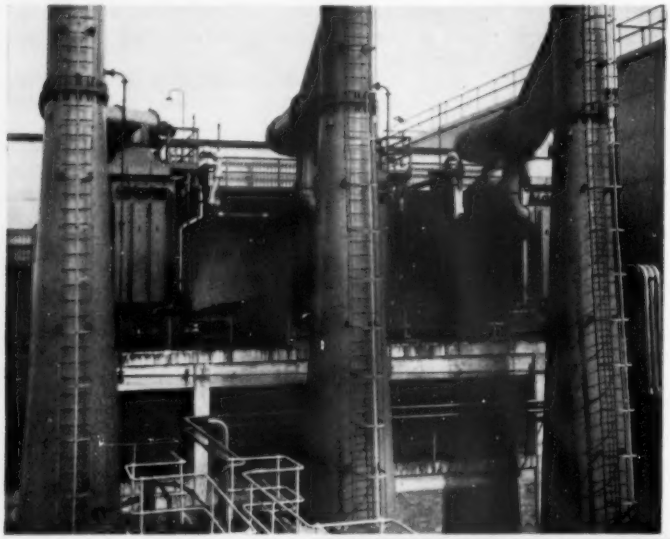


Fig. 3 (left).—Outside view of plant showing pre-evaporators behind three main chimneys

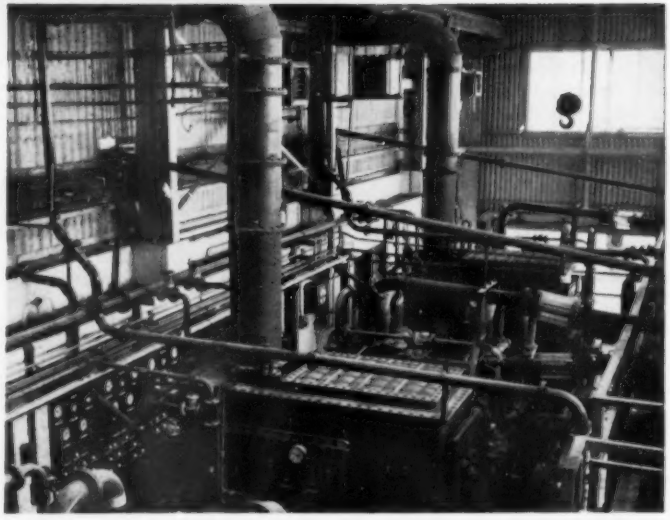


Fig. 4 (below).—Two of main evaporators with the comprehensive instrument panel on the bottom left

10 ft. × 8 ft. × 8 ft.; the cooler separator 7 ft. diameter × 7 ft. high; each chimney is 120 ft. high × 4 ft. 6 in. diameter.

Fig. 3 is an outside view of the plant showing the pre-evaporators situated behind the three chimneys and Fig. 4 shows two of the main evaporators with the comprehensive instrument panel to the left, which is fronted by a plate glass window so that the operators can easily see all the instruments without having to go into the instrument room. The plant is fully instrumented and is complete with automatic alarms and shuts down in the case of a fault arising.

Fig. 5 also shows two of the main evaporators, but, in addition, the cooler separators are on the right. Fig. 6 shows the ground-floor view of the plant with the centrifuges just discernible on the left.

The normal quantity of waste pickle liquor is now of the order of 1,000 gallons per pickle line per hour, and the acid strength leaving each line approximates to 12 per cent W/W H_2SO_4 and 19 per cent W/W $FeSO_4$, from which the weight of dry monohydrate, *i.e.* without residual acid or moisture being taken into account, would be of the order of 590 tons per week.

Nordac indicated that the residual acid and moisture would not be more than 3 per cent and 6 per cent respectively, although, in operation, an acid content as low as 0.9 per cent has been achieved.

Waste pickle liquor is pumped from the same holding tank as was used for neutralizing, by means of the same pumps, to the pre-evaporators where it is concentrated to approximately 15 per cent W/W, and which is a form of economizer making use of

the waste heat from the main evaporators; the waste pickle liquor being circulated over the outside of lead tubes which carry the vapour and combustion gas mixture leaving the evaporators. Water is evaporated from the waste pickle liquor by drawing across the tubes a large volume of air.

From here the liquor goes to the main evaporators, each of which is fired by means of two submerged combustion burners operating on high-sulphur coke-oven gas and which give a range of 4,000/12,000 cubic feet of gas per hour. The liquor is concentrated in these evaporators to 45/50 per cent H_2SO_4, and then, with the crystals already formed, is air lifted into the cooler separator. The concentrate is kept agitated and the clear recovered acid is drawn off at the top of the cooler while the slurry is taken from the bottom to the centrifuge; the liquor recovered from the centrifuge is returned to the separator and the dry monohydrate recovered is conveyed to an overhead storage hopper.

The gases, before passing to the pre-evaporator, are scrubbed by high-velocity water jets to remove any acid mist being carried over. The pre-evaporator condensate is used as the scrubbing water, and, being slightly acid, is used to dilute the recovered acid before re-use in the pickle lines.

The monohydrate is sold to sulphuric acid manufacturers and transported to their works by road transport. The same transport is used to bring back to The Steel Company the recovered iron oxide.

Materials of construction were given a great deal of thought, and each centrifuge is made from an

(*Continued in page* 680)

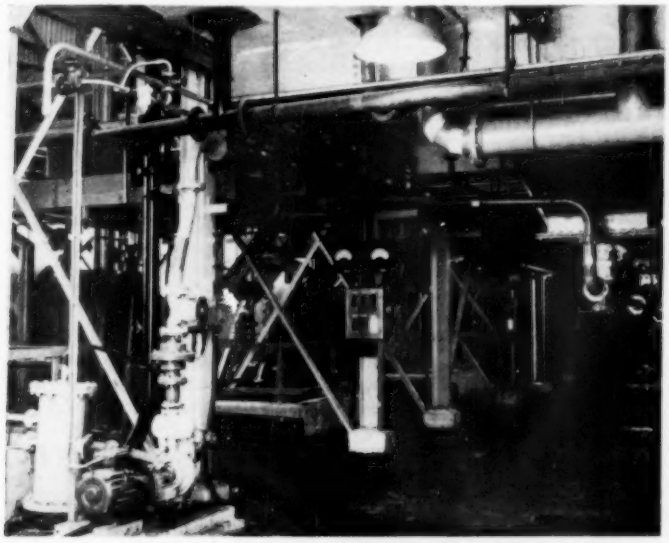


Fig. 5 (*above*).—*Two of main evaporators with the cooler separators on the right of the picture*

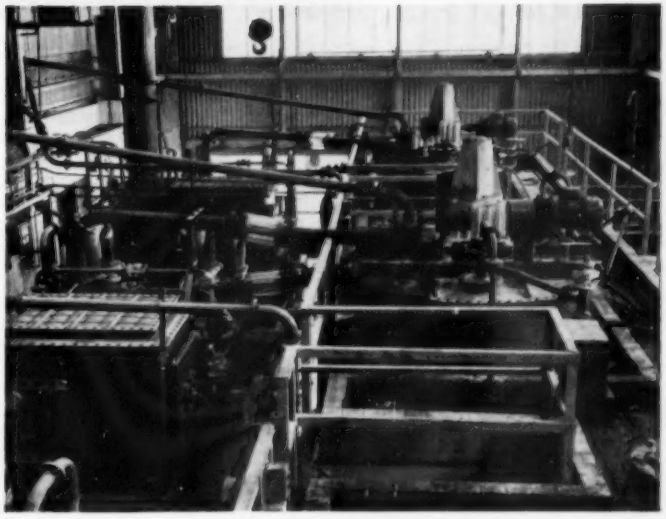


Fig. 6 (*right*).—*Ground-floor view of plant with centrifuges just discernible on the left*

Treatment of Waste Acid

(*Continued from page* 679)

18 per cent nickel, 18 per cent chromium, 3.7 per cent molybdenum and 3.4 per cent copper bearing steel. The cooler separators are made from steel, water jacketed and homogeneously lead lined. The main evaporator is made from steel lined with thick tough rubber and protected by an acid-resistant brick inner lining. The burners are made of ordinary cast iron and refractory lined. The pre-evaporators consist of a steel structure wholely covered with rubber and the tank at the bottom further protected by means of an inner lining of acid-resisting brick. The tubes carrying the waste gases are made of lead.

The building designed to house this plant contains separate gas-booster and air-compressor rooms, as well as a contactor room.

One section of the plant went into operation during August, 1959, followed by the second section in October, 1959, and the third section at the beginning of February, 1960.

Up to the end of November, 1959, more than 590,000 gallons of 28 per cent acid had been recovered and used on the pickle lines and more than 750 tons of monohydrate had been sold.

The proving run on the first unit consisted of an uninterrupted run of 120 hours which gave the following results:—

Pickle liquor temperature in the pre-evaporator trough: 53° C.

Scrubber tank temperature: 88° C.

Evaporator temperature: 114° C.

Condensate rate (2 per cent H_2SO_4 W/W) 290 gallons per hour.

Gas flow 11,000 cu. ft. per hour.

Air flow 64,000 cu. ft. per hour.

Pre-evaporator exit temperature 76° C.

B.O.V. rate 1,460 lb. per hour (to replace the $FeSO_4$ removed).

Acid in top of separator: specific gravity 1.37 at 83° C.

Recovered acid, average rate 720 gallons per hour, at 26 per cent W/W/ H_2SO_4.

Analysis

Name of tank	Percentage W/W $FeSO_4$	Percentage W/W H_2SO_4
First set of readings:		
Pickle liquor sump	15.1	8.75
Pre-evaporator ..	18.6	10.8
Top of separator ..	4.27	43.5
Recovered acid tank	3.32	26.0
Condensate ..	—	2.1
Monohydrate —	—	2.28
Second set of readings:		
Pickle liquor sump	15.1	9.6
Pre-evaporator ..	18.3	11.8
Top of separator ..	3.9	43.5
Recovered acid tank	3.01	28.1
Monohydrate ..	—	3.04

Throughout:

0.8 to 0.9 tons per hour monohydrate (average figure).

Pickle liquor 1,000 gallons per hour.

Evaporation rate in pre-evaporator 2,320 lb. of H_2O per hour.

Evaporation rate in evaporator 4,630 lb. of H_2O per hour.

UNITED STEEL OFFER UNIVERSITY SCHOLARSHIPS

WITH the object of continuing to remain in the forefront of scientific research and technical advance in iron and steel manufacture, The United Steel Companies Ltd. are to offer up to ten university scholarships each year, tenable at any university in the United Kingdom. Each scholarship will be worth £500 per annum and its value will not be affected by parental income.

The scholarships will be offered to boys proceeding to a university to take full-time courses leading to approved degrees in appropriate branches of science or engineering. The company is also prepared to consider a limited number of applications from students of non-science subjects, recognizing that there is a place in industrial management for the good arts graduate.

It is intended that the scholarships should provide industrial as well as academic training, and arrangements will be made for successful candidates to receive industrial experience with the company before going up to university and also to undertake vacation work in industry. In addition to the scholarship award, students will be paid a subsistence allowance during these periods of industrial training.

Applications for the scholarships will be considered from students in their final school year who have achieved the necessary academic standard and have also been offered a place at a university. In addition to academic qualifications, the selectors will be looking for character, initiative and independence of mind.

On completion of their degree courses, scholars will have the opportunity of joining the company's graduate training scheme, which already has the approval of the appropriate professional institutions. During this period, they will be paid salaries at the current rates for graduate apprentices.

Booklets and application forms are now available on request to the company and enquiries should be addressed to University Scholarships, The United Steel Companies Ltd., The Mount, Broomhill, Sheffield, 10.

Recent Developments in EXPLOSIVE FORMING AND WELDING in the U.S.A.

Explosive Forming

EXPLOSIVE forming is not a new process by any means and most people have seen every-day examples of it. Industrially, it is a method of controlling a force, produced by explosion, to force metal against a containing die of the desired shape. Its usefulness is not limited to the supermetals and experience has shown that it can eliminate many difficulties associated with the fabrication of parts from thin sheets of steel and most of the common aluminium alloys.

The Ryan Aeronautical Company in the United States, at present concerned with the manufacture of pods and pylons for the latest transport plane of the Douglas Aircraft Company, the DC-8, has developed the technique for efficient construction assemblies in aircraft part production. Using nearly ten tons of titanium each month on the production line, it was essential to cut the high costs of conventional forming and in an effort to meet the exacting tolerances demanded by the Douglas specifications, extensive experimentation and tool design was carried out.

The nose cowl on the DC-8 pod readily adapted itself to explosive forming. Originally made of five separate parts formed on presses and welded together, it is now formed in a matter of seconds with a small explosive charge. A sheet of metal, about $\frac{1}{8}$ in. thick, in the form of a truncated cone, is placed inside the die which is then filled with water. A vacuum is created between the cone and the sides of the die by pumping out the air. A high explosive is fired inside the cone, forcing the metal to take the shape of the prescribed curved mould line, the water acting as both a force conductor and shock dampener.

Fig. 1.—Explosive forming of DC-8 nose cowl part

Fig. 2.—Finished pod of the DC-8 Jetline

A new assembly building with a working area of some 30,000 square feet was specially designed to handle the increased output and bring all parts of the pod and pylon programme together in a common finishing and shipping point.

Welding

Another recent development to overcome problems of expanding production has been the combination of two modern fabricating methods, heliarc

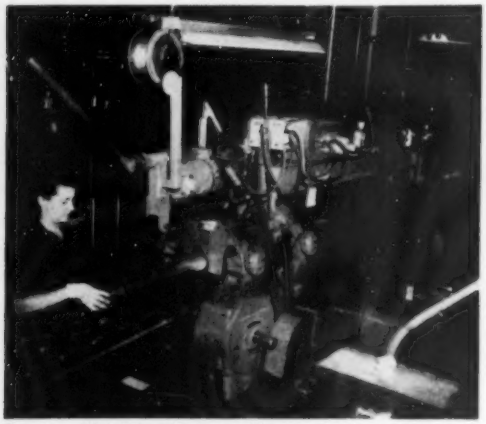


Fig. 3.—Welded cylinders roll out of the tube-welding machine. During the welding process, the cylinders move under a sigma torch within this machine at a speed up to 200 in. per minute

and sigma welding, by the Aluminium Goods Manufacturing Company of Wisconsin, makers of Mirro aluminium products. It has helped the company meet the need for cartridge tanks. Heliarc welding speeds up to 60 in. per minute and sigma welding speeds up to 200 in. per minute have been developed as a result.

Cartridge tanks are made from 34-in. wide coils of aluminium. Blanks are stamped out of the aluminium, cleaned and formed into open cylinders about 4½ in. in diameter, and fed into a modified tube-welding machine equipped with a sigma welding torch. The ends of the welded cylinder

Fig. 4.—The second phase of production is completed by this automatic heliarc welding machine. The cup will be welded to the cylinder in 12½ seconds

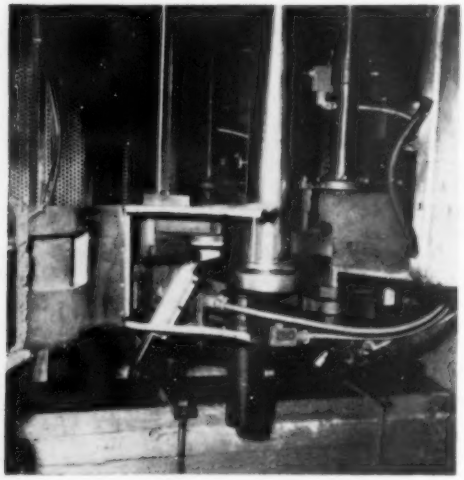


Fig. 5.—To avoid contamination by oxygen and nitrogen during the welding process, titanium alloy is welded in a plastic bag filled with argon gas

are trimmed and a cup, made of 10-s.w.g. aluminium, is sigma welded to one end of the tube and held in place by a back-up mandrel inserted in the cylinder. The unit is inserted in a jig which rotates under a heliarc torch, designed to include an automatic control which stops the machine after a weld is finished. A grooved collar is pressed on the open end of the aluminium tube, completing the cartridge.

Titanium plays an important part in many fields of engineering construction, where the emphasis is on lightweight strength, but for some years, attempts to develop its obvious potential have been delayed by the metal's brittleness and its resistance to fabrication. The failure of a titanium rotor in 1954 was attributed to the presence of too much hydrogen, and attempts to remove the hydrogen from the metal, resulted in extensive research programmes to discover new techniques for fabricating the metal, sponsored to a large extent by Pratt and Whitney Aircraft, a division of United Aircraft Corporation.

One of the most difficult operations was that of welding. Due to its highly reactive nature, special precautions to avoid embrittlement of the weld metal by contamination with oxygen and nitrogen from the atmosphere, were necessary. Experimentation led to the technique of welding in a plastic bag filled with argon gas, and later the torch was followed by "trailing cups" containing a blanket of argon. Fig. 5 shows this method of welding being carried out on an aircraft component.

STEELWORKS AUTOMATION

ASSOCIATED ELECTRICAL INDUSTRIES LTD. and Davy-United Ltd. have formed a jointly financed Steelworks Automation Unit to apply new automatic control techniques to the processing of steel and also of non-ferrous metals.

An Introduction to the

THEORY AND PRACTICE OF FLAT ROLLING—1

By the late C. W. STARLING, B. Eng., A.M.I.Mech.E.

AUTHOR'S PREFACE

THE rolling process has developed as an art over several centuries. In recent years, however, due to the stimulus of war and the higher standard of living, the demand for rolled steel has increased at a phenomenal rate and in order to cope with the demand, science has been applied in an attempt to obtain a full understanding of the process and speed up developments.

During the last two or three decades the Universities have carried out a great deal of fundamental research on rolling and Research Associations have made a substantial contribution towards the application of this research, in addition to their own original work. Outstanding in this respect is the work carried out under the auspices of the British Iron and Steel Federation before the war and continued and greatly expanded by the British Iron and Steel Research Association since the war. This has resulted in a flow of highly technical papers, almost all of which assume that the reader has a specialized knowledge of the rolling process and a sound mathematical background. There is, however, a scarcity of literature on the rolling process suitable for study by operatives with little technical training and this book is intended to fill this need by starting from the first principles of mechanics and advancing to a non-mathematical explanation of the basis of rolling theory, with particular reference to the practical application of the theory. There is no doubt that an understanding of the theory of the rolling process improves operating technique on any mill, but on the modern high-output continuous mills, it is rapidly becoming essential.

As this book is written primarily for rolling-mill operatives, words are used whenever possible in preference to mathematical symbols and in many cases the words are supplemented by simple diagrams. It is expected, however, that it will be a useful introduction to the subject for students and technicians intending to specialize in rolling and serve also as a text book for engineering students wishing to acquire a general knowledge of metal working.

In preparing a book of this nature, reference is made to many published works and it is intended that the bibliography should serve as an acknowledgement to the many authors. It is fitting to mention also the heavy secretarial work in preparing the manuscript, carried out so efficiently by Mrs. P. J. Jones and the necessary but tedious job of proof reading, in which the Author was assisted by his wife.*

ELEMENTARY MECHANICS

BEFORE considering the elements of rolling theory, it is essential to have a clear understanding of the meaning of several technical words or phrases. Words such as elastic, plastic, stress and strain are in common daily use, but mathematically they each have a well-defined meaning.

An Elastic Material

If a load is applied to a bar made from an ideal elastic material, the bar will increase or decrease in length, depending on the direction of the load and this change in length will be proportional to the applied load. When the load is removed, the bar will return to its original length.

An experiment can be carried out with a bar of rubber, say 10 in. long and $\frac{1}{2}$ in. square. If a 1-lb. weight is attached to the bar, it will stretch a small amount and the increase in length can be measured. When the weight is removed, the bar returns to its original length. Addition of a 2-lb. weight will double the increase in length which was obtained by adding the 1-lb. weight. The length of the bar can be measured for a range of weights and a graph of weight/length plotted as shown in Fig. 1 (*a*).

*Unfortunately, the author's untimely death prevented the compilation of this bibliography.

The present series of articles, of which this is the first, was planned and discussed with the late author a considerable time before his regretted death and following publication in this form the complete work will be published as a book by the University of London Press.

Mr. C. W. Starling, who was assistant manager, cold rolling, at the Abbey Works of the Steel Company of Wales Ltd., at the time of his death, was a graduate in Engineering at Sheffield University. He served an 18-month apprenticeship with B.S.A., on completion of which he joined Armstrong Siddeley and later Napier's Ltd., on research work. He was then appointed to head a research team into rolling mills technique with B.I.S.R.A. at Sheffield, and some years later became research engineer with W. H. A. Robertson and Co. Ltd.

In 1956 he joined the Steel Company of Wales Ltd. as a technical assistant, rolling mills.

The late C. W. Starling, B.Eng., A.M.I.Mech.I.

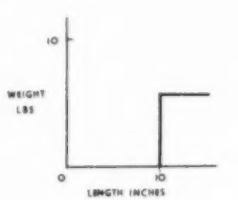
For a perfectly elastic material this will be a straight line and a similar straight line can be obtained if the weights tend to reduce the length of the bar.

A *tensile load* is a load tending to stretch the bar and can be considered to be positive in the graph, while a *compressive load* tends to reduce the length of the bar and can be considered to be negative. The graphs for tensile and compressive loads can then be combined as in Fig. 1 (*b*).

A Plastic Material

If a load is applied to a bar from an ideal plastic material, the bar will resist it until the load reaches a certain value, after which the bar will stretch and continue to stretch until it breaks. If the load could be removed after the bar began to stretch, it would stay in its new form and not return to its original length as would an elastic material.

A graph of weight/length for a plastic material will then be as shown in Fig. 2 (*a*). As before, the same effect is obtained from a compressive force and the combined graphs for tensile and compressive forces are shown in Fig. 2 (*b*).



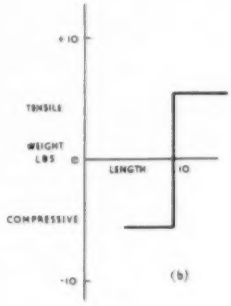
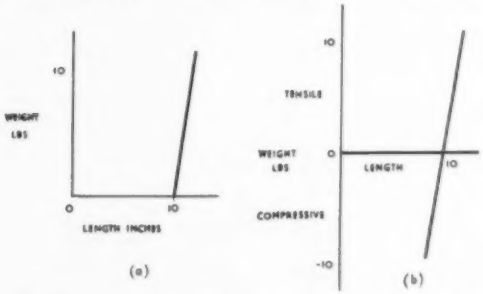
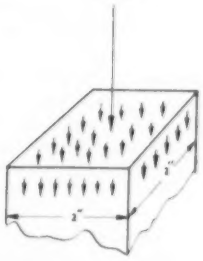


Fig. 1 (left)

Fig. 2 (above)

Fig. 3 (right)





Strain

Strain can be defined as the change in form produced in a material by the action of a load upon it. *Tensile Strain* is obtained from a load tending to stretch the material and *Compressive Strain* is obtained from a load tending to compress the material. In each case the strain is measured by the ratio of the change in length to the length of the original material.

Expressing this as an equation—

$$\text{STRAIN} = \frac{\delta l}{l} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where l is the original length of the bar

δl is the change in length after a load is applied.

For example, if a bar is 10 in. long and it stretches 0.1 in. under a certain load,

$$\text{Tensile strain} = \frac{0.1}{10} = 0.01$$

It will be obvious that this is a ratio and, therefore, has no dimensions; it is not necessary to know the applied load when measuring strain.

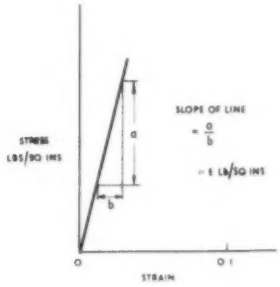


Fig. 4

Stress

Stress can be defined as the combination of forces which are called into play in a material to resist the tendency of a load upon it to produce strain.

To illustrate this, consider a 2-in. square bar under a load of 10,000 lb., as shown in Fig. 3. The load will be resisted by an infinite number of small forces spread throughout the fibres of the bar and the stress in the bar is the sum of these small forces in 1 sq. in. of cross-section.

Expressed as an equation,

$$\text{Stress} = P/A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where P = applied load

A = cross-sectional area of the material under load. The stress in the bar shown in Fig. 3 will, therefore, be

$$\frac{10{,}000}{4} = 2{,}500 \text{ lb. per sq. in.}$$

The Stress/Strain Curve

The graph of weight/length, Fig. 1 (*a*), can now be replotted as a stress/strain curve. It will still be a straight line, but the scales will be changed, as in Fig. 4.

The stress/strain curve for an elastic material is very important and is used in many engineering calculations. As a straight line is obtained, it follows that

$$\frac{\text{STRESS}}{\text{STRAIN}} = \text{A CONSTANT.}$$

and this constant is known as the Modulus of Elasticity or Young's Modulus.

This is usually given the symbol E and the equation becomes

$$\frac{\text{STRESS}}{\text{STRAIN}} = E \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

which is known as Hookes Law.

Substituting from Equations (1) and (2)

This becomes $E = \dfrac{P/A}{\delta l/l}$

$$\text{or } P = \frac{EA\delta l}{l} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

To obtain Young's Modulus for any particular material, an experiment can be carried out and the stress/strain curve plotted. The slope of the straight line is measured from the graph, and allowing for the appropriate units from the scales of the graph this is Young's Modulus.

Young's Modulus for steel varies from 30,000,000 to 36,000,000 lb. per sq. in.

The weight/length graph for a plastic material, Fig. 2 (*a*), can also be replotted as a stress/strain curve as shown in Fig. 5.

The Stress/Strain Curve for Steel

The stress/strain curve for steel is of vital importance and enters into every aspect of metal working. It is rather an unusual curve, as steel can be either elastic or plastic.

If the original experiment with a bar of rubber and weights is repeated with a bar of steel and much heavier weights, it will be found that at first steel behaves in exactly the same way as rubber, with, of course, very much smaller increases in length. The stress/strain graph can be plotted and a straight line obtained as before.

When a certain load is reached, however, the steel suddenly yields and becomes plastic, the length increasing rapidly under constant load. The point at which the change occurs is known as the *Yield Point*. If steel was an ideal plastic material it would continue to stretch under constant load until the breaking point was reached and the stress/strain curve would be a combination of Figs. 4 and 5, as shown in Fig. 6.

Steel, however, is not a theoretically perfect plastic material, as another factor called *Work Hardening* appears. Any rolling-mill operator knows from experience that as steel is worked it

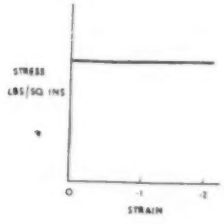
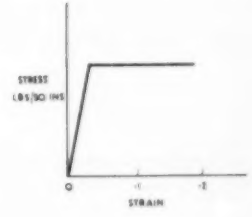


Fig. 5 (left)

Fig. 6 (right)



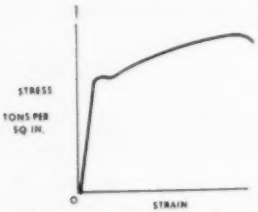


Fig. 7 (left)

Fig. 8 (right)

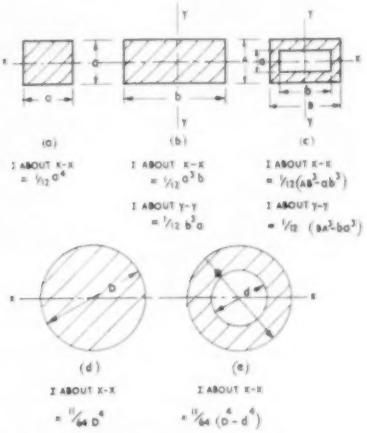
rapidly becomes harder and more resistant to deformation. Stretching a bar under load causes work hardening and in practice it is found that the addition of further small weights will be required to keep the bar stretching until breaking point is reached.

The form of the stress/strain curve for steel obtained in practice is then as shown in Fig. 7. The aim in temper rolling an annealed sheet is to remove, as far as possible, the horizontal part of the curve at the yield point and give a smooth change from the elastic to the plastic state.

Bending of Beams

When loads are applied along the axis of a bar, the bar will stretch or compress in accordance with Hooke's Law. If, however, the loads are applied at an angle, a much more complicated system of strain arises and the bar will tend to bend. The amount by which a bar bends will depend, among other factors, on Young's Modulus and the *Moment of Inertia*.

Moment of Inertia is defined mathematically, but it is sufficient here to say that it is a measure of the resistance of a beam to bending. The numerical values of the Moment of Inertia for various sections which may arise in rolling-mill calculations are shown in Fig. 8, the symbol I normally being used, with units of inches^4. With an unsymmetrical section, it is essential to take the Moment of Inertia about the correct axis. If the bar has a rectangular cross-section it is obviously easier to bend it about axis x—x than about y—y. This is shown by the Moment of Inertia of $\frac{1}{12}$ ba^3 about x—x, which is far lower than the Moment of Inertia of $\frac{1}{12}$ ab^3 about y—y.



The study of the bending of beams under various combinations of loads is highly mathematical and it is considered sufficient at this stage to quote the magnitude of deflection for a few simple cases which may arise in rolling-mill calculations without giving the method of obtaining the formulae.

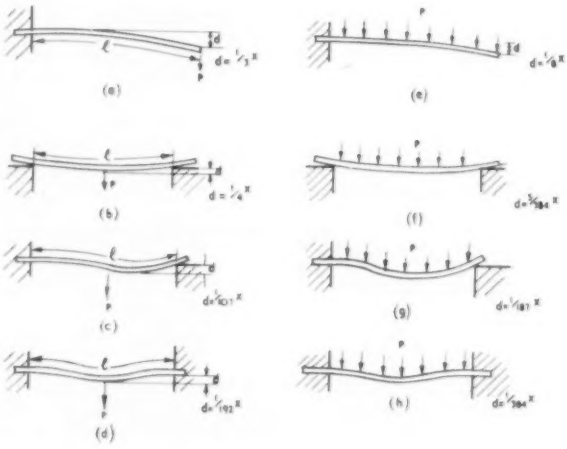
Fig. 9 shows a beam under various types of loading. In each case the deflection is given the symbol d and it is proportional to the quantity $\frac{Pl^3}{EI}$

where P = load in lb.
l = length of beam, in.
E = Young's Modulus in lb. per sq. in.
I = Moment of Inertia in in.^{4}

Put $x = \frac{Pl^3}{EI}$ .....(5)

The beam shown in Fig. 9 (*a*) is held rigidly at one end and a load P is attached to the other end.

Fig. 9 (right)



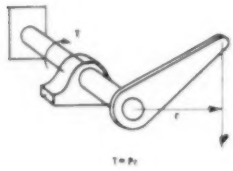


Fig. 10

Deflection $d = \frac{1}{3} x$ inches.

If the same beam is supported at each end, Fig. 9 (*b*), the deflection at the centre will be much less and $d = \frac{1}{48} x$.

If one end is rigidly held and the other supported as in Fig. 9 (*c*), the deflection is even less and $d = \frac{1}{107} x$.

The deflection is least when the beam is rigidly fixed at both ends as in Fig. 9 (*d*) and is then $d = \frac{1}{192} x$.

Figures 9 (*e*) to 9 (*h*) show the same beam with the load spread evenly along its full length.

Twisting Moment or Torque

In addition to being stretched, compressed or bent, a bar can be twisted by the application of suitable loads.

Consider a bar clamped firmly at one end and supported in a bearing at the other end. A lever is attached to the free end, as shown in Fig. 10, and a load applied to the lever. If a bar is made from an elastic material it will twist under the load and return to its original position when the load is removed. The angle of twist will be proportional to the load applied and in the same way as the stretch of an elastic bar under a tensile load is proportional to the applied load.

The *Twisting Moment or Torque* on the bar is defined by the equation—

$$T = Pr \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where P = load applied to the lever
r = perpendicular distance from load to shaft
T = torque.

The torque on a shaft driven by either gears or a belt can now be calculated. If a motor exerts a torque T on a shaft 1, Fig. 11, the load on the gear teeth at the point of contact is $P = T_1/r$. This load will act on the teeth of the mating gear and the torque on shaft 2 will then be $T_2 = PR$.

But $P = \frac{T_1}{r} \therefore T_2 = \frac{T_1}{r} R$

or $\frac{T_1}{T_2} \frac{r}{R}$ $\quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$

This means that the torque on the second shaft is greater than that on the first shaft by the ratio of gear radii.

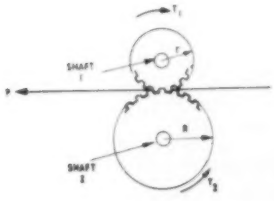


Fig. 11 (left)

Fig. 12 (right)

Shearing Stress

When a shaft is subjected to a twisting moment, internal forces are called into play to resist the twisting, in the same way as stress opposes the tendency to lengthen a bar under a tensile load. The stress in this case is known as a *Shearing Stress* and varies uniformly from zero at the centre of the shaft to a maximum on the periphery.

The shearing stress in a shaft can be calculated from the equation—

$$T = \frac{\pi}{16} D^3 f \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

where T = torque applied to shaft
D = shaft diameter
f = shearing stress.

Horse-power Transmitted

In the case of shafts driving machinery, one end is usually attached to a gear, coupling, or pulley, through which torque is applied to the shaft. The shaft is free to rotate in bearings and drive other members through a coupling or gear at the other end, the torque applied being sufficient to overcome the resistance of the driven member.

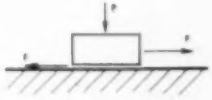
A shaft driving machinery is doing work and the rate at which it is doing work is fixed by the speed of the shaft and the applied torque. The rate of doing work is usually measured in horse-power and the relationship between horse-power and torque can be obtained from the equation—

$$\text{Horse-power} = \frac{2 \pi N T}{33{,}000} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

where N = shaft speed in r.p.m.
T = torque in ft.-lb.

Friction

The process of rolling is made possible by the friction between the material being rolled and the rolls. If it were possible to reduce friction to a negligible quantity it would be impossible to enter the strip into the rolls, and if the rolls were screwed



down on to the strip they would simply skid without biting. As cold-mill operators will know, it is possible to approach this condition with highly polished rolls and strip and a good lubricant between them.

It is, therefore, essential to know something about the laws of friction before considering rolling theory.

Consider a perfectly flat table with a block of wood standing on it, as shown in Fig. 12. The weight of the block is P lb. If a string is attached to the block and a small load F applied horizontally, the block may or may not move, depending on the amount of friction between the block and the table. If there is no movement, the forces on the block must be in equilibrium and the frictional force is, therefore, equal to F and acting opposite to it along the table. As force F is increased, the resisting frictional force will also increase to keep the block in balance, but it can only rise to a certain maximum which is fixed by the friction between the block and table. If the block and table were polished and well greased, the maximum frictional force would be small. On the other hand, with very rough surfaces in contact, the frictional force would be high and a greater value of F would be required to move the block.

The magnitude of the force F required to overcome the maximum frictional resistance can be obtained simply by multiplying the weight of the block P by a factor known as the *Coefficient of Friction*. That is :—

$$P \times \mu = F \quad \ldots\ldots(10)$$

where μ is the coefficient of friction.

It will be noticed that no mention has been made of the size or shape of the block and it will be seen from the equation that the frictional resisting force is a function of the weight of the block and the coefficient of friction only.

This equation could be evolved by simple experiments and the value of μ obtained for various materials. The laws of friction obtained from these experiments apply for most types of surfaces in contact, but in the rolling process extreme pressure and temperature conditions are obtained in the roll gap and the laws of friction must be modified. Many attempts have been made to measure experimentally the value of μ for various rolling conditions (references 1, 2, 3 and 4) the latest and most successful being by *Ford*. Table I shows the values of μ for various conditions in cold rolling obtained by Ford.

It is much more difficult to estimate the value of μ for hot rolling as the surface of the rolls varies considerably within a very short period. A highly polished roll becomes rough almost immediately, particularly in a roughing mill, and may develop crazy cracking and fire cracks quite soon after going into service. Various authorities have reached different conclusions about this value of μ and the results have been critically analyzed by *Underwood*.

For the purpose of calculations later in the book, it is assumed that μ in hot rolling lies somewhere between the curves shown in Fig. 13, depending on the condition of the rolls.

TABLE I—*Values of the Coefficient of Friction in Cold Rolling from Experiments by Ford and Whitton*
Smooth Rolls = 9 Microinches
Rough Rolls = 20 ,,

Lubricant	Pass No. from annealed	Material being rolled—smooth rolls				Rough rolls
		Mild steel	Aluminium	Brass	Copper	Copper
Rolls and strip	1	0.085	0.092	0.093	0.093	0.124
Clean and dry	3	—	0.099	—	0.069	0.113
Water	1	—	—	0.061	0.075	—
Soluble oils	1	0.061 to 0.070	—	0.052	0.054 to 0.065	0.085
	3	0.050 to 0.056	0.082	0.046 to 0.059	0.056 to 0.061	—
Paraffin	1	0.080	0.081	0.067	0.067	—
	3	0.060	0.070	—	0.068	—
Graphite in oil	1	0.072	0.055	—	—	—
	3	0.047	—	0.055	0.054	0.064 to 0.069
Palm oil	1	—	0.066	—	0.075	0.087
Olive oil	2	0.057	—	0.055	0.058	0.080
Castor oil	3	0.045	0.057	—	0.046	0.056
Lanoline	4	0.041	0.025	0.043	—	—

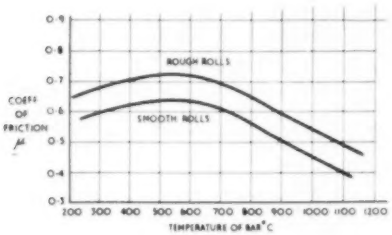


Fig. 13 (left)

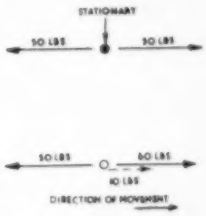


Fig. 14 (right)

Resultant Forces

It will be essential later to understand what happens to a body which has several forces acting upon it. There is a branch of applied mathematics devoted to this problem and it can become very complex, but at this stage only the bare essentials essentials necessary for understanding work in later chapters will be mentioned.

In order to obtain some idea of the meaning of the resultant of two forces, imagine a small trolley mounted on ball-bearing castors on a highly polished floor. If two strings are attached to this trolley and two people pull against each other, each with a load of 50 lb., the trolley will not move. If, however, one man pulled with a force of 60 lb. the trolley would move in his direction as though there was a single force of 10 lb. on it, as shown in Fig. 14.

Consider now what would happen if two men were pulling at an angle, as shown in Fig. 15 (*a*). The trolley would obviously move in some direction between the two forces, as shown by the dotted line. It so happens that there is a simple method of finding the direction in which the trolley would move and the equivalent load on it in this direction. A line is drawn of a length proportional to one of the loads, *e.g.*, 1 in. = 50 lb. A second line is drawn in the direction of the other load to the same scale. If a parallelogram is completed and the diagonal drawn from the trolley, this diagonal will indicate the direction of movement, and its length will indicate the equivalent force drawn to the same scale as the other sides (Fig. 15 (*b*)).

If a fixed point is now considered instead of a trolley, the two forces at this point will have the same effect as one force whose magnitude and direction is obtained by completing the parallelogram in the same way.

It follows from this that any single force in any direction can be split up into two forces acting at the same point in any two directions and the magnitude of the new forces obtained by drawing a parallelogram with the original forces as a diagonal, as shown in Fig. 16. More complicated systems of forces can be broken down to pairs and eventually to single forces to find the resultant reaction at a given point.

Ohms Law

If a conducting circuit is made from one terminal of a battery to the other, electricity will flow round the circuit. This flow is maintained by the *Electromotive Force* (*E.M.F.*) developed in the battery and this force is measured in *Volts*.

Under steady-flow conditions, the rate at which the electricity flows can be measured by taking the quantity of electricity which passes any point in the circuit in one second. This is known as the *Current* and is measured in *Amperes*.

The flow of electricity can be compared to water flowing in a pipe system. The flow of water, under a fixed head, will be fast or slow, depending on the diameter of the pipes and whether there are any restrictions in the circuit. Similarly, the flow of electricity under a fixed electromotive force will depend on the size of the conductors and any restrictions in the circuit, and this is known as the *Resistance* of the circuit, which is measured in *Ohms*.

The relationship between Current, Resistance and Electromotive force for any circuit can be obtained from *Ohms Law*, which is the fundamental equation for all electrical calculations.

(*Continued in page* 690)

Fig. 15 (left)

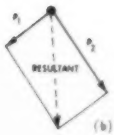


Fig. 16 (right)

Strain-ageing in Rimming Steel

(*Continued from page* 646)

to follow convincingly the changes in yield point and other properties associated with strain-ageing.

Acknowledgements

The authors wish to record their thanks to Mr. R. A. Hacking, O.B.E., director of research, Richard Thomas & Baldwins Ltd., for permission to publish this paper, to Mr. C. R. Pipe for his constant encouragement and helpful discussion, and to Mr. B. Blake for assistance with the practical work.

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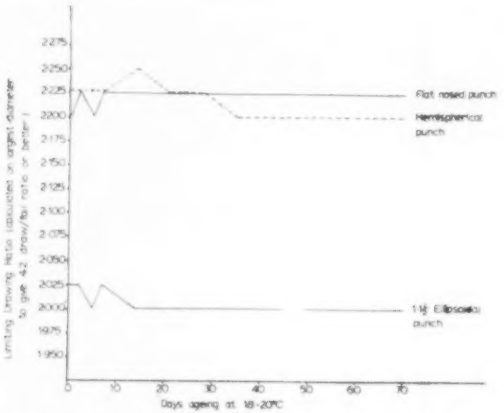

Fig. 6.—Variation of Limiting Drawing Ratio with ageing time at room temperature

APPENDIX

THE work described above was carried out on material which had been subjected to accelerated strain-ageing. In order to confirm the results obtained on the Swift cupping press for material which had been aged at room temperature, some sheets of the same material as that used for the accelerated ageing tests were stored in a room thermostatically controlled at 19° C. (± 1° C.).

Swift cupping tests were carried out using only the two standard punches and the 1:1½ ellipsoidal punch. The results which are set out in Table XI and are shown graphically in Fig. 6 show that there is no significant difference in the Limiting Drawing Ratios after ageing for periods up to 70 days. The conditions of testing (blankholder pressure, lubrication and punch speed) were as already described above.

The other parameters measured after room-temperature ageing showed similar curves to those obtained after accelerated ageing.

An Introduction to the Theory and Practice of Flat Rolling

(*Continued from page* 689)

This states that—

EMF = Current × Resistance,

or expressed mathematically,

$$C = \frac{V}{R} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

where C = current in amperes
V = EMF in volts
R = resistance in ohms.

Electrical Power

Power is the rate of doing work and is measured by the energy developed per second or per minute. Electrical power P is given by

$$P = VC$$

and if V is 1 volt
and C is 1 amp,

the power developed, P is defined as 1 *Watt*.

In general $P = VC$ ..... (12)

where P is in Watts
V is in Volts
C is in Amps.

The watt is a small unit of power and generally a *Kilowatt*, equal to 1,000 watts is used.

The unit of power used in mechanical engineering is *Horsepower*, and as both units are the rate of doing work, there is a direct connection.

This is 1 Horsepower = 746 Watts
or 1 Kilowatt = 1.34 *Horsepower*.

The consumption of electrical power depends on the power and the time over which the power is applied. For commercial purposes it is usual to measure consumption in *Kilowatt-Hours* and one Kilowatt hour is known as a *Unit* of electricity.

Then $KH = U$ ..... (13)

where K is in Kilowatts
H is in Hours
U is in Units.

(*Series to be continued*)

SHEET METAL DATA SHEET 9

Press-Tool Nomenclature

Compiled by J. W. Langton, M.B.E., B.Sc.(Lond.), M.I.Mech.E.

PRESS-TOOL NOMENCLATURE

PRESS-TOOL nomenclature is very loose and often ambiguous, so in all discussions on press tools it is advisable for all to have a common understanding of any terms used. The definitions given here are of fairly common acceptance.

GENERAL

Press Tools

This is an all-embracing term covering any or all of the tools used in presses, irrespective of press type. This is the best general term to use.

Press-brake Tools

A similar term for any or all of the bending and forming tools used in press brakes.

Dies

Often used in a general sense in the same way as the term press tools, and there may be a separation into top and bottom dies. If used in the singular, as the die, it usually refers to the bottom or female press tool only.

Punches

Often used with dies to cover press tools generally—as punches and dies. In the singular, it refers to top or male press tool. These terms punches and dies are not always applied to punching tools, but can cover general press tools for many operations.

Sub-press Tool

A self-contained press-tool unit in which the top and bottom tools are arranged so that the alignment between them is always preserved.

Pillar Tools

Press tools in which the working tool parts are mounted in a pillar die set where the top and bottom parts are coupled together with guide pillars. Really an elementary form of sub press. Pillars usually work in separate guide bushes.

Gang Tools

Where several similar pairs of tools are mounted together on a common bolster.

Progressive or Follow-on Tools

Tools in which a series of operations is carried out progressively on the strip or component as it is moved through the tools. Most elementary type here, say, for washer production—where at first stage centre hole is pierced, followed at second stage by blanking.

Compound Tools

A general term for press tools where a number of operations are combined in a single stage, e.g. if washer tool pierced and blanked washer in one stage—tool would be compound. Term not used too often—terminology is usually to couple by the operation combined—such as blank and pierce; cut and draw, etc., etc., but its use does indicate the combination is done in one stage *i.e.* follow-on blank and pierce, or compound blank and pierce for the two cases of washer tools just mentioned.

Tool Parts

Some very general terms for main parts of press tools are:

Bolster—Main bottom tool.

Punch / Punch-holder } Main top tool.

Die-block—Main part of bottom tool.

Punch — ,, ,, ,, top ,,

Pressure pad / Pressure ring } Part used to apply pressure to strip or component.

CUTTING TOOLS

The main types of tools in this class are:

Blanking Tools—Tools for blanking or cutting out usually for strip, where the part cut out is the part required. Sub main types: "drop through"; blank pushed through bottom die block—"lift back"; blank lifted back to top of bottom tool by pressure pad—"inverted"; die parts reversed—die block in punch holder with surround press ring; punch in bolster.

Drop through—used in main where hole in press bed permits blank to drop.

Lift back—when drop-through is not possible or if flat blank is desirable.

Inverted—where some virtue in lifting blank in die block and also to keep blank flat.

Piercing and Punching Tools

Tools to pierce or punch out from strip or components, the part punched out not being required.

Piercing and punching used mostly synonymously.

Multi-piercing—a tool to pierce a number of holes simultaneously.

Perforating tools—virtually multi-piercing tools for small holes.

9 SHEET METAL DATA SHEET

Press-Tool Nomenclature (Cont.)

Notching Tools

Tools used to cut away parts of strip or components (parts not required) cutting on three sides or part periphery only.

Shaving tools are used to trim or shave blanks to finer limits after blanking.

Trimming tools are used to trim the edges of strips or components to a certain shape.

Compound or combination cutting tools are then, those in which some of the above operations are combined.

BENDING AND FORMING TOOLS

Descriptive true name covers a vast range of tools. General distinction between this group and drawing tools is that here while the metal is stressed beyond its elastic limit, there is essentially no change in metal thickness. Distinction between bending tools and forming tools (if necessary) is difficult—certainly in a few words here.

Most common bending tools are:

Vee-bend Tools—for bending metal to angle—usually a right-angle as for flanging.

U-bend Tools—for bending metal to U form.

Flange Bend—for production of flanges, usually at right-angles—of small even widths—metal held under pressure.

A few definitions found in bending:

Bend Radius—radius of inside of bend—minimum radius has a definite relationship to stock thickness and physical properties of metal.

Bend Allowance—The developed length of the bend along the neutral axis.

FORMING TOOLS

Forming tools are difficult to classify into groups or types. Common operations carried out in forming tools are hole flanging, wiring and false wiring, curling, bending, joggling.

The drawing of sheet metal may be regarded as a cold-forming process, where the metal blank is forced to shape while under pressure. There is some alteration of the metal blank thickness in practically all cases.

The first main separation into groups of these tools are:

(*a*) Single-acting drawing tools, designed to work in single-acting presses, where the blank-holding pressure comes from some source such as springs, rubbers, air or oil cushion, usually mounted below the press bed, and

(*b*) double-action drawing tools, designed to work in double-action presses, where the blankholder pressure is supplied by the outer ram.

There has been a steady process of the replacement of (*b*) by (*a*) for some years.

Term draw tool usually implies that only one drawing operation is involved; otherwise referred to as first-operation draw tool, etc. *N.B.*—Adjectives single and double acting are often omitted.

SINGLE-ACTION TOOLS

First operation has common form—plug block or bolster—pressure ring round block—top draw punch and ejector—pressure pins connecting pressure ring with pressure medium.

Re-draw Tools—are for operations after first. Two main forms—one similar to first operation, the pressure ring fitting inside the component from the previous operation, the pressure ring fitting inside the component from the previous operation, or reverse draw, in which the component, is drawn inside out. The choice of type depends on the job.

DOUBLE-ACTION TOOLS

The first or single draw tool type is of the push-through type. A pressure ring is mounted on the bottom bolster, with aperture that of outside of tool. To the press outer ram is fixed the blank holder, and to the inner ram the drawing punch. The outer press ram descends first, holds the blank under pressure, while the punch descends and draws the metal into the bottom pressure ring and finally pushes it through.

In the top return type, the component after drawing is not pushed through but is brought back to the top of the pressure ring. This type is used where there is any embossing etc. required on box of component. Re-draw double-action tools may take the same form as above, with a pressure ring form replacing the blank holder. The reverse draw type as previously mentioned may also be used.

A few common terms used when drawing metal :

Draw Bead—bends fitted to pressure faces to control the flow of the metal.

Harredge or Burr—the rough edge left after cutting.

Cupping—the drawing of a cup.

Drawing Radius—usually the radius over which the metal is drawn (the radius of bore of top punch in single-action types—of bottom ring in double-action types).

Ironing—the reduction of the thickness of walls of the shell.

Wrinkling—a wavy condition on the shell due mainly to insufficient pressure on blank or component during drawing.

COMBINATION TOOLS

Good press-tool designing calls for an examination of a possible combination of the basic operations where possible and economically desirable. Thus there are a myriad of possible tool combinations, cut and draw, cut, draw and pierce, blank and pierce, etc., but the exact combination is clearly expressed in the titles.

In considering combination of operations, due regard should be paid to first costs and maintenance (including the effect of abuse) as well as production considerations.

INSTITUTE OF SHEET METAL ENGINEERING

WORKS TOUR IN SOUTH WALES

Details have now been finalized in connexion with the next in the series of biennial works tours, which this year is being staged in South Wales. The tour party assembles in Cardiff on the evening of October 3 and proceeds via Swansea and Merthyr Tydfil to Newport on October 7, visiting, in all, ten works en route. A detailed itinerary and application form for participation have been circulated to all members and very nearly enough applications have been received to date to fill all the available places on the tour. Places are being allocated in order as applications are received and applicants in excess of the number that can be accommodated will be placed on a waiting list in case of reservations being cancelled.

The programme of the tour is as follows:—

Sunday, October 2

Party assembles in Cardiff.

(In view of the wide diversity of centres from which members have to travel, all members participating in the tour make their own travel arrangements to and from South Wales.)

Monday, October 3

9.15 a.m. Depart Park Hotel for visit to Guest Keen and Nettlefolds (South Wales) Ltd., Cardiff.

1.00 p.m. Luncheon by invitation of the Company.

2.30 p.m. Visit to Simmonds Aerocessories Ltd., Treforest.

4.00 p.m. Depart to Swansea.

Tuesday, October 4

9.30 a.m. Visit to British Iron and Steel Research Association, Sketty Hall.

1.00 p.m. Luncheon.

2.30 p.m. Visit to Aluminium Wire and Cable Co. Ltd., Port Tennant.

5.00 p.m. Return to Swansea.

Wednesday, October 5

9.00 a.m. Visit to Morris Motors Ltd., Llanelly.

1.00 p.m. Luncheon.

(*Continued overleaf*)

Mr. ALLEN E. GILBERT

Chairman of Council of the Institute

AT the last Council Meeting of the Institute, which was the first meeting of the new Council following the Annual General Meeting, Mr. Allen E. Gilbert was elected Chairman in succession to Mr. F. B. Hooper, who had completed his two-year term in that office.

Mr. Gilbert was educated at Rotherham Grammar School and Sheffield University, before joining the firm of J. J. Habershon and Sons Ltd., which company he has continued to serve up to the present day. He was appointed a director of the company in 1940, and in 1949 he founded a subsidiary, The Edmonton Steel Strip Co. Ltd. of which he is managing director.

When these two companies became part of the Firth Cleveland Group of companies a few months ago, he joined the board of Firth Cleveland Steel Strip Ltd.

Mr. Gilbert, who is well known to the majority of members, was elected to the Council of the Institute in 1949 and has consistently played an effective part in its activities; he acted as leader of the parties of members which took part in the tours of works in Switzerland and Germany in 1954 and 1956, and for the past year he has been vice-chairman of the Council, as well as acting as chairman of the Institute's Sheffield Committee.

2.30 p.m. Visit to The Steel Company of Wales Ltd., Velindre.
5.00 p.m. Return to Swansea.
7 for
7.30 p.m. Tour Dinner, Mackworth Hotel, Swansea.

Thursday, October 6
9.00 a.m. Visit to The Anglo-Celtic Watch Co. Ltd., Ystradgynlais.
1.00 p.m. Luncheon.
2.30 p.m. Visit to Hoover (Washing Machines) Ltd., Merthyr Tydfil.
5.00 p.m. Depart to Pontypridd.

Friday, October 7
9.15 a.m. Visit to Lines Brothers, Merthyr Tydfil.
1.00 p.m. Luncheon.
3.00 p.m. Visit to Pilkington Bros. Ltd., Pontypool.
5.00 p.m. Depart to Newport. Tour ends.

SPECIAL CONFERENCE ON COLD EXTRUSION OF STEEL

Since technical discussion on the production of steel components by a cold extrusion process was initiated in this country at a special conference organized by the Institute in 1953, slow but steady progress has been taking place in the development and application of the process. A number of companies are now operating cold extrusion processes under licence and a considerable amount of investigational and development work has been carried out, both by private firms and some Government establishments. It has appeared timely that a further opportunity be provided for reviewing the stage in development which has now been reached and discussing some of the findings at a rather more practical level than was possible in 1953 in the light of experience gained since that date.

The next special conference on The Cold Extrusion of Steel has therefore been planned to be held in Sheffield on November 21-23 next, and preliminary announcements to this effect have already been made on this page.

The programme will comprise some eleven papers, the greater proportion of which will be of a practical nature covering such aspects of the subject as tool materials, coating and lubrication, equipment, design and application. These papers will be presented and discussed in five sessions, the first session commencing at 2.30 p.m. on Monday, November 21, subsequent sessions being held in the morning and afternoon of each of the following two days. All sessions will be held in the Memorial Hall of the City Hall, Sheffield. During the conference a number of films will be shown demonstrating the operation of the process, while typical components manufactured by cold extrusion processes will be on display.

Detailed programmes and application forms for tickets for this meeting will be sent to all members of the Institute in the next few weeks. Any others interested in the possibility of attending this conference are invited to record their interest with the Hon. Secretary, The Institute of Sheet Metal Engineering, John Adam House, John Adam Street, Adelphi, London, W.C.2, so that a copy of the programme can be sent to them when ready.

TRIPARTITE CONFERENCE IN 1961

Plans are progressing for the three-cornered meeting to be held in London in May, 1961, between the American Pressed Metal Institute, the German Forschung für Blechverarbeitung and the Institute of Sheet Metal Engineering. Although details have yet to be finalized it is anticipated that the meeting will comprise two half-day sessions at which papers will be presented by representatives of each of the three bodies outlining developments and operation of the pressworking industries in each of the countries. Arrangements will also be made for the overseas participants in the meeting to visit a number of works in the London and Birmingham areas.

BRANCH PROGRAMMES

The new session of Branch meetings starts in October and all Branches have planned full and varied programmes. The first meeting of the **Midland Branch** falls on **October 5,** and takes the form of a Works Visit, which is to be followed by a Supper and Social Evening at the White Horse, Congreve Place, Birmingham. The **North-West Branch** is holding its first meeting on **October 20** when Mr. J. Hayes (Rockwell Machine Tool Co. Ltd.) will lecture on " Automatic Presswork in Multislide Machines." A Discussion Forum with an expert panel in attendance on " Economic Considerations in the Use of Sheet Metal " will be held at the opening meeting of the **South-West Branch** on **October 4.**

The full programme of all Branch and Institute activities for the 1960-61 Session will be issued to members shortly, but any non-member who is desirous of obtaining information concerning future Branch meetings is recommended to communicate with the appropriate Branch Secretary as under:—

Midland Branch, E. N. Salmon, The Austin Motor Co. Ltd., Longbridge, Birmingham, 31.
Wolverhampton Section, S. Blower, Rubery Owen and Co. Ltd., Temple Street, Wolverhampton.
North-West Branch, A. C. Vickers, Renold Chains Ltd., Renold House, Wythenshawe, Manchester.
South-West Branch, P. S. Yates, Nott's Industries (Frome) Ltd., Carley Works, Frome, Somerset.

SHEET METAL NEWS

FEATURING EVENTS AND PERSONALITIES IN THE INDUSTRY

BRITISH WELDING DELEGATION VISITS U.S.S.R.

Trip organized by B.E.A.M.A.

A DELEGATION from the British welding industry visited the U.S.S.R. from June 22 to July 8 at the invitation of the State Scientific and Technical Committee of the U.S.S.R. Council of Ministers. The delegation was led by Mr. D. J. W. Boag, managing director of Rockweld Ltd., and the visit will be followed by a reciprocal visit to the U.K. by Russian technical experts. The exchange of visits was arranged by the British Electrical and Allied Manufacturers' Association.

Members of the British delegation were: Mr. D. J. W. Boag (managing director, Rockweld Ltd.) Leader; Mr. R. L. Swan (director and general manager, Lincoln Electric Co. Ltd.); Mr. G. M. Harvey (development director, British Oxygen Gases Ltd.); Mr. G. H. Moule (chief engineer, heating and welding dept., A.E.I. (Manchester) Ltd.); Mr. W. S. Simmie (welding engineer, Pressed Steel Co. Ltd.); Mr. D. Wyllie (welding engineer, Babcock and Wilcox Ltd.); Mr. R. H. Boughton (welding engineer, English Electric Co. Ltd.); and Mr. T. F. Tribe (managing director, British Federal Welder and Machine Co. Ltd.).

The general impression of the delegation on their visit to the U.S.S.R. was extremely good. The hospitality and friendship of all the Russian people met was said to be heartwarming and the delegation were unanimously impressed by the sincerity of all the people they met, both in the course of their business and other people met outside.

The delegation visited The Institute of Machines, Moscow; The Institute of Metallurgy, Moscow; The Moskvitch Car Works, Moscow; The Institute of Electric Welding Machines, Leningrad; The Metallic Works, Leningrad; The Paton Institute of Electric Welding, Kiev; and Kherson Shipyard, Kherson.

The technological work of the Institutes was excellent and in particular the application of the theory to the development of welding techniques and processes was outstanding.

Some members of the British Welding Delegation to U.S.S.R. Left to right: R. H. Boughton, W. S. Simmie, G. H. Moule, T. F. Tribe, G. M. Harvey

Many semi-automatic processes had been developed to undertake duties covered by hand welding in the U.K.; these processes and the equipment itself seemed to be of high quality, although the speed of welding was little faster than many hand-welding techniques used in the U.K. The development of hand welding in the U.K. was undoubtedly ahead and particularly in the field of high-current welding and the use of iron-powder-loaded electrodes which in many cases gave a rate of productivity equal to, or better than some of the semi-automatic processes.

In the field of fully-automatic arc welding their rate of progress was about equal to that of the U.K. although widespread use is now made in the U.S.S.R. of electroslag welding—a process developed in the Paton Institute.

Of particular interest was the manner in which the Technical Institutes investigated problems from industry and developed a full solution of not only the welding, but of all other aspects, typical examples being prefabricated oil-storage tanks of capacity of 5,000 cubic metres, and inflatable steel pipelines up to 6-in. diameter.

In the resistance-welding field practice had developed along similar lines to U.K. practice, although the U.S.S.R. seemed to lag slightly on the high production special purpose machines. The number of large 3-phase machines for welding light alloys was impressive and it was believed that the main application was for rolling stock.

Interesting new techniques being developed were friction welding; semi-submerged arc welding of light alloys; electron-beam welding; hand surfacing by submerged-arc welding, with bead widths up to 3 inches.

Although there is much technological advance in welding, it would appear that some industrial plants are still using old processes due to shortage of production of new equipment.

(*Continued in page* 696)

COURSE IN FUEL EFFICIENCY

N.I.F.E.S. Annual Refresher Course is firmly established as the opportunity for works managers, works and plant engineers and members of the technical staffs of industrial firms and municipal and public undertakings to acquire up-to-date information and guidance on the economic use of fuel—so vital to increased efficiency and productivity.

The Seventh Annual Residential Refresher Course will be held at the Clarendon Laboratory, Oxford, from September 26 to 30, 1960. This course covers a wide range of subjects and each of the lectures is presented by a speaker eminent in the special field to be covered and who will pay particular attention to practical application.

Included in the subjects will be: Coal and the Industrial Consumer; Role of the Central Engineering Workshop in the Maintenance Plan; Oil Burning Efficiency; The Efficient Use of Gas in Industry; Recovery and Use of Waste Heat in Industry; Improvement of Electrical Load Factor; Automation and its Impact on the Plant Engineer; Factors affecting the choice of Industrial Boiler Plant; Efficiency in Drying Processes; Industrial Application of Low Temperatures; The Value of Instruments and Automatic Control; Conservation of Water; The Efficient Use of Compressed Air; Appraisal of Atomic Energy in relation to Industry; Incineration and Utilization of Waste Materials; Five Years Progress in Fuel Utilization.

The fee for the course including accommodation is £15 15s., and full details may be obtained from the Course Secretary, N.I.F.E.S., Ailsa House, 181, King's Road, Reading, Berks.

British Welding Delegation

(*Continued from page* 695)

The shipyard at Kherson was working closely with the Paton Institute and was using all the new techniques applicable to ship-building.

The programme and social arrangements made by the Academy of Sciences Paton Institute were excellent, and it is hoped that this first delegation will be the forerunner of many more equally successful and informative technical exchanges in the welding industry, and the delegation assured the Russians of an equally cordial reception in the U.K. during their forthcoming visit in September.

Sandvik Conveyors Assist in Battery Production

PRITCHETT AND GOLD AND E.P.S. CO. LTD. have been manufacturing all types of lead-acid batteries since 1882 and production and development is carried out at a well-equipped and modern factory at Dagenham Dock, Essex, extending over 17½ acres. Dagenite Batteries have been used by Rolls-Royce for over 50 years.

Research plays a very important part at Dagenham and, besides progress accelerated by two world wars, many other major contributions to the design of batteries (for commercial and domestic use) have resulted from the work carried out by the companies' technicians.

Among these developments is the production of microporous P.V.C. "Porvic" battery separators which have revolutionized the durability and reliability of the car batteries in which they are used. During the production of these separators extensive use is made of Sandvik stainless-steel band conveyors, three of which are installed, each 16 in. wide and 60 ft. long. Porvic strips 40 in. long are loaded on to the belt to be carried through a 20 ft. tunnel filled with live steam. As they emerge from the tunnel they are flattened by sponge rubber rollers before passing under cold water sprays which set the strips so that they may be handled without distortion. The object of the operation is to remove wrinkles and to anneal and relax strains which have been built into the material in the prior processes of the manufacture.

The conveyor belts are each driven by one-h.p. electric motor powered by a Croft's worm gear and Varatio straight line gear box operating at 360 r.p.m.

Magnus Chemical Co. New Delivery Service

THE Magnus Chemical Co. Ltd., Salisbury Road, Uxbridge, Middlesex, state that all Midland enquiries and deliveries will be dealt with from their office at 751, Bristol Road South, Northfield, Birmingham 31, telephone No. Priory 4979. An improved delivery service for the Midlands generally will be introduced and collections can be made from the new stores—Magnus Chemical Co. Ltd., c/o Jennings Transport, London Road, Curdworth, nr. Birmingham.

THE installation of equipment at the New Zealand Works of the Northern Aluminium Co. Ltd., an artist's impression of which is given below, will begin in September and it is expected that production will start in May of next year. The works will occupy a site of 25 acres at Wiri, some 14 miles to the south-east of Auckland, and will have, initially, an annual capacity of 5,000 tons of sheet, circles and heavy gauge foil, with potential for expansion to a considerably greater tonnage. The main item of equipment will be a 72-in. reversing hot mill, which is being transferred from the Banbury Works, where an 84-in. reversing mill has recently been installed. A 60-in. four-high mill is also being transferred from Banbury and a pair of flat sheet mills are being shipped from the Kingston, Ontario, Works, of the Aluminum Co. of Canada.

SIR CHARLES GOODEVE TO BE NEXT PRESIDENT OF THE IRON AND STEEL INSTITUTE

AT a meeting of the council of The Iron and Steel Institute held on July 13, 1960, it was agreed unanimously to propose Sir Charles Goodeve, O.B.E., D.Sc., F.R.S., for nomination as president-elect of the Institute at the autumn general meeting in November. Sir Charles will succeed Mr. W. F. Cartwright as president at the annual general meeting in May, 1961, and will thus be in office at the time of the Institute's proposed special meeting in the U.S.A. in October, 1961.

SIR CHARLES GOODEVE

Charles Frederick Goodeve was born in Canada in 1904. He graduated at Manitoba University in 1919, where he carried out research on electrochemistry. In 1927 he was awarded a scholarship to University College, London, where he was appointed lecturer in physical chemistry in 1930 and reader in chemistry in 1937.

During World War II he served in the Royal Navy. He played an important part in countering the magnetic mine, and later developed and produced the Hedgehog anti-submarine weapon. From 1942, as a Deputy Controller, he was in effective control of the whole research and development programme of the Royal Navy, and it was for his services in this connexion that he was knighted in January, 1946.

Sir Charles left the Admiralty to become Director of BISRA on its foundation in 1945. He has succeeded in combining his administrative duties with original research, and has made significant contributions to knowledge of the physical chemistry of metallurgical processes. He was President of the Faraday Society from 1950 to 1952, and President of the Chemistry Section of the British Association in 1956. In 1958-59 he was Master of the Worshipful Company of Salters. Sir Charles, who was elected a Fellow of the Royal Society in 1940, received the honorary degrees of Doctor of Science from the University of Manitoba in 1946 and from the University of Sheffield in 1956.

As Director of BISRA, Sir Charles became an honorary member of Council of The Iron and Steel Institute in 1945; he was elected a Vice-President in 1956.

NEW COMPANIES

"Ltd." is understood, also "Private Co." Figures — Capital, Names — Directors, all unless otherwise indicated.

WILLIAM BOOTH (METAL WORK), Old Road, Warrington, Lancs. June 7. £10,000. *To take over the bus. of sheet metal workers and light engineers carried on as "William Booth and Co." at Warrington, etc. Wm. Booth and Doris Booth.*

METAL FACTORS. June 8. £100. *To carry on bus. of importers and exporters of and dealers in metals, scrap metal, etc. Clara Brie and Anita Fraser.*

PRECI-SPARK, High Street, Syston, Leics. June 8. £500. *To carry on bus. as profile grinding and electro-spark machinists, engineers, etc. Ralph G. Jones and Mrs. D. L. Jones, Raymond R. Jeal.*

HARVEY SMITH (LUTON), 26, Victoria Street, Luton, Beds. June 16. £1,000. *To carry on bus. of sheet metal workers, heating and ventilating experts, etc. Directors not named.*

J. DAW PRODUCTIONS, 65, Lower Essex Street, Birmingham. June 20. £100. *To carry on bus. of dealers and workers in metals, etc. Arthur H. Daw and Mrs. Vera C. Daw.*

ROWLAND BARKER AND SON, 45, Chelsea Road, Sheffield, 11. June 23. £100. *To carry on bus. of manufacturers and manipulators of metal, etc. Rowland Barker, Mrs. W. L. Barker, John R. D. Barker, and Miss Angela C. Barker.*

BAYTON SHEET METAL, Torrington Avenue, Tile Hill, Coventry. June 24. £1,000. *To take over bus. of sheet metal workers. Edwin Briggs, Frederick H. Ridgewell.*

ALCAN ENFIELD ALLOYS. June 27. £100. *To acquire from Enfield Rolling Mills, the fee simple of certain works situate at Bradford, Yorks, and to acquire the bus. of production of aluminium alloys from scrap at present carried on by Enfield Rolling Mills (Aluminium). Directors not named.*

MIDLAND COLD FORMING ALLIANCE, 120, Colmore Row, Birmingham, 3. June 27. £1,000. *To carry on bus. of manufacturers in metal and other substances, etc. Leslie Marshall, Stanley R. Cresswell, Dudley B. Russell, Frederick V. Wallis.*

WALTER T. INESON, Chesham Road, Barnsley, Yorks. June 29. £2,000. *To take over bus. of sheet metal workers. George L. Simmons, Ernest E. Perkins, Percival R. Adamson and Walter T. Ineson.*

BALLARD (WINCHESTER), Winnall Close, Winchester. June 30. £25,000. *To take over bus. of smiths, welders, light steel and metal workers. Edward H. A. Ballard and Mrs. Dorothy Ballard.*

STAINLESS SHEET AND BAR, 101, Whitwell Road, London, E.13. July 1. £1,000. *To carry on bus. of metal merchants, metal and alloy makers, etc. David Balbes, Edgar H. Hobbs, John Hooper.*

SAMUEL KRINKS AND SONS, Soho Pool Works, Hockley, Birmingham 19. July 1. £5,000. *To carry on bus. of manufacturers of and dealers in metals and alloys, etc. Mrs. I. L. Krinks, Samuel G. Krinks, Mrs. Audrey S. Grove and Mrs. Iris P. Hirst.*

Agency for Broaching Machines

THE Elgar Machine Tool Co. Ltd. of 172-178, Victoria Road, Acton, London, W.3, have been appointed the exclusive distributors in the United Kingdom for the complete range of hydraulic broaching machines manufactured by Varinelli of Milan as well as for the Polak die casting machines.

APPOINTMENTS and STAFF CHANGES

Dr. N. A. de BRUYNE

Mr. R. F. G. LEA

Mr. S. N. Kinsley, deputy secretary of the research and development department of **The United Steel Companies Ltd.**, succeeded Mr. Geo. H. Davison as secretary of the department on the latter's recent retirement. Mr. Davison, who has been with the company for 27 years, will continue to serve in a full-time advisory capacity for the time being.

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The **Appleby-Frodingham Steel Co.** have made the following new appointments: Mr. R. Wogin, previously manager of the Appleby melting shop, has been made assistant works manager (steel); Mr. R. Johnson has been made melting shops manager, responsible for both Appleby and Frodingham melting shops, together with the basic slag plant and the refractories section; Mr. A. F. Jessop has been appointed manager of the Appleby melting shop and Mr. W. L. Willsher manager of the Frodingham melting shop.

Mr. H. R. Brunyee, works manager (services) at the **Steel, Peech and Tozer** branch of the United Steel Companies, retired on July 31 and is succeeded by Mr. M. Thomas, previously assistant works manager.

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Capt. F. T. Boswell, R.N. (retd.), who joined **Samuel Fox and Co. Ltd.** earlier this year as assistant welfare officer has now been appointed welfare officer in succession to Major W. G. A. Carrington, who has retired after 17 years' service.

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Mr. D. R. Ward-Jones has been appointed general manager of the ore mining branch of the **United Steel Companies Ltd.** in succession to Mr. T. B. Adkins, general manager for the last 13 years and who retired recently after 56 years with the company.

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Lt.-Col. P. F. Benton Jones, who is managing director (mining and carbonisation) of United Steels, has relinquished the position of general manager of **United Coke and Chemicals Co. Ltd.** and is succeeded by Mr. A. L. Curtis, operations manager.

Dr. N. A. de Bruyne, the founder of **CIBA (A.R.L.) Ltd.** of Duxford, Cambridge, has resigned from the position of managing director in order to devote more time to research, especially to the development of scientific instruments. His resignation will take effect at the end of 1960 but he will continue to be a member of the board. On and after January 1, 1961, Mr. R. F. G. Lea, O.B.E., M.A., will become deputy chairman of the company and will also act as joint managing director with Mr. D. A. Hubbard.

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At the annual general meeting of **Pinchin, Johnson and Associates Ltd.** held recently, Sir Horace W. Clarke, Mr. Noel H. Docker and Sir James Reid Young having decided to retire, did not seek re-election as directors and Mr. A. H. Wilson, F.R.S., was appointed chairman of the company and Mr. C. F. Kearton, O.B.E., deputy chairman. Mr. Wilson is a deputy chairman and a managing director of Courtaulds Ltd. and Mr. Kearton is also managing director of Courtaulds Ltd. and among other appointments in the Courtaulds Group is deputy chairman and senior managing director of British Celanese Ltd. and chairman of Group Developments Ltd.

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The British Welding Research Association have appointed Mr. J. D. D. Morgan and Dr. L. M. Wyatt to the Research Board. Mr. Morgan is with the General Chemical Division of Imperial Chemical Industries Ltd., and is the Chairman of the I.C.I. Welding Panel. Dr. Wyatt is the Chief Metallurgist of the Central Electricity Generating Board.

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Mr. R. Waller has been appointed mechanical maintenance superintendent at **Steel, Peech and Tozer,** a branch of The United Steel Companies Ltd., in succession to Mr. A. Stark who has retired after 22 years' service.

Mr. D. A. HUBBARD

Mr. Andrew Jollie has resigned from his position as director and general manager and is succeeded by Mr. T. S. Kilpatrick, the director, hitherto, of Workington Iron and Steel Co.

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Mr. T. Wintrup, sales manager (engineering) of **Distington Engineering Co. Ltd.,** another subsidiary of the United Steel Companies Ltd., has been appointed purchasing and contracts manager and will be responsible to the commercial manager for the purchasing activities of the company and for the placing of all sub-contracted work. Mr. Wintrup is succeeded by Mr. J. Tonks, senior draughtsman.

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The **Brockhouse Organization** announces the retirement of Mr. W. Brunt from Brockhouse Castings Ltd. He is succeeded as general manager by Dr. J. Grieve.

In appreciation of his past services Mr. Brunt has been appointed a director of the company and will continue to be available in a consultative capacity.

The Mond Nickel Co. Ltd. and its subsidiary company, **Henry Wiggin and Co. Ltd.** have made the following Board changes: Mr. G. Archer relinquishes his position as chairman of both companies and is appointed president; Mr. Ivon A. Bailey is appointed chairman and chief officer of Mond and Wiggin; Dr. L. B. Pfeil is appointed vice-chairman of Mond; Mr. J. O. Hitchcock managing director of Mond and deputy chairman of Wiggin, and Mr. H. W. G. Hignett managing director of Wiggin.

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Honeywell Controls Ltd. have appointed Mr. A. Stephens as senior flow engineer at the company's Greenford (Middlesex) head office and Mr. R. W. H. Vivian has been appointed at the Greenford head office to specialize on application engineering using the company's electric miniature instrumentation, which is being introduced in the United Kingdom this year.

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Mr. H. M. Henderson, who is at present managing director of Unisteel Structural (Pty.) Ltd., of Cape Town, South Africa, has been appointed director and general manager of the **Workington Iron and Steel Co.** branch of The United Steel Companies Ltd. He succeeds Mr. T. S. Kilpatrick who has become director and general manager of the Steel, Peech and Tozer branch. Mr. Henderson will take up his new appointment in November, 1960, with the intention of relinquishing it on June 30, 1962.

Mr. T. Sanderson, director and general works manager of Workington Iron and Steel Company, has been appointed deputy general manager. Mr. H. Darnell, previously chief engineer, succeeded Mr. Sanderson as general works manager.

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J. H. Fenner and Co. Ltd. Hull, have appointed Mr. S. Parker home sales manager. Mr. Parker joined Fenner in 1950 as West Midlands representative and was promoted to Midlands Regional manager in 1954.

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Commander Geoffrey Clarke has joined the **Vitreous Enamel Development Council** as its new general manager in succession to Mr. Ken Jones, who is assuming an industrial appointment in Africa. For the past two years Commander Clarke has been assistant to the director of the British Productivity Council and prior to that served in the Royal Navy, which he joined at the outbreak of war as a rating.

Mr. W. H. ADAMS

Mr J. D. ECCLES

The board of **Head Wrightson and Co. Ltd.,** announce the appointment of the following general managers among their subsidiary companies: Mr. W. H. Adams of Head Wrightson Iron and Steel Works Engineering Ltd., Mr. J. D. Eccles of Head Wrightson Steel Foundries Ltd., and Mr. G. W. Wilson of The Cupola Mining and Milling Co. Ltd.

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The governing council of the **International Institute of Welding** has elected Fred L. Plummer International vice-president of the Institute and he assumed office at the Annual Assembly in Liege, Belgium.

Mr. Plummer is National secretary of the American Welding Society and chairman of the American Council which selects delegates and directs the American activities of I.I.W. He has served two terms as president of the A.W.S.; was director of engineering for the Hammond Iron Works; headed the Bailey Bridge Mission to Japan for the U.S. Army Corps. of Engineers, holds degrees from Ohio University and the Case Institute of Technology. During his earlier years he was Associated Professor at Case and has been responsible for the design of many important structures including an eight-million dollar bridge project in Cleveland, Ohio.

* * *

Union Carbide Ltd., Alloys Division announce that Mr. M. A. Clifton has joined the outside sales staff as a representative in the southern area. Mr. Clifton will be based on the London head office at 103, Mount Street, London, W.1.

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Styrene Co-Polymers Ltd. have appointed Mr. K. E. Piggott, chief chemist, to the post of technical manager and Mr. P. G. Salmon to marketing manager.

Mr. Ernest Coverdale, chairman and joint managing director of **Permoglaze Holdings Ltd.,** and Mr. Peter Coverdale, joint managing director, have joined the board of directors of **Blundell, Spence and Co. Ltd.**

At the same time, Mr. E. B. Calvert, chairman and managing director of Blundell, Spence and Co. Ltd., and Mr. A. F. Bacon, executive director, have been appointed directors of **Permoglaze Holdings Ltd.** and **Permoglaze Ltd.**

These appointments are made following the announcement that an agreement had been reached for a merger to take place between the two companies.

* * *

The **O. Hommel Co.,** Pittsburgh, ceramic colour suppliers, have acquired the services of Don Schreckengost, well-known designer and colour authority, to help carry out the company's intention to support and develop new uses for ceramic colours. Don Schreckengost has had considerable experience in the colour and design field and during a varied career has received numerous awards in the fine art and industrial consumer product fields; for some time he was Professor of Industrial Ceramic design at New York State College of Ceramics, Alfred University and is currently a fellow of The American Ceramic Society, vice-chairman of the design division, and a member of the Inter-Society Colour Council and Industrial Designers' Institute.

* * *

B. Elliott and Co. Ltd. have acquired the Mortimer Engineering Co., Acton Lane, London, N.W.10, which will operate in future as the **Mortimer Engineering Co. Ltd.** under the direct control of its new executive directors, Mr. E. W. Kelleher (managing director) and Mr. F. E. Wilson (director).

George Kent Concentrate on Instrumentation

WITH the recent transfer of all the interests, assets and production capacity of their Steering-Gear Division to the ownership and management of Cam Gears Ltd., George Kent Ltd. can now devote their manufacturing capacity almost exclusively to industrial instrumentation and process control, and mechanical meters.

Mr. Harold Leese, who was a member of the Kent Organization for 33 years and a director from 1933 until 1948, is chairman of Cam Gears and the substantial Kent interests are represented on the new board by three Kent directors. The enlarged Cam Gears Co. has been further strengthened by the cash purchase of a 20 per cent shareholding by the Ross Gear and Tool Co. Inc. of Lafayette, the largest independent steering-gear manufacturer in the United States.

The older and main instrumentation and meter business of the Kent Company will—apart from the changes given—continue to be transacted from the factories in Luton and the Kent subsidiaries and representation throughout the world.

Record Size Tonnage Oxygen Plant for Margam Steelworks

A CONTRACT to build and operate the biggest tonnage oxygen plant serving the iron and steel industry in Western Europe has been placed with British Oxygen Gases, Ltd., by The Steel Company of Wales Ltd.

The plant, which is to be installed at the Margam Works, will have a capacity of 566 tons of oxygen per day. It will also be the first tonnage oxygen plant for blast furnace air enrichment in Western Europe. It is scheduled to come into operation by January, 1962. Costing well over £1 million, the plant will enrich by 4 per cent a total blast volume of 200,000 cu. ft. of air a minute. Final oxygen content of the enriched blast will thus be 25 per cent.

The higher oxygen content will give a substantial increase in the iron produced by the furnaces. In addition to increasing output from existing capacity, this technique will lead to greater efficiency in the blast furnace process. The installation will thus be making a valuable contribution to the current development of The Steel Company of Wales.

Firth Cleveland Steel Strip Signs East German Contract

FOLLOWING their representation at the Leipzig Trade Fair, Firth Cleveland Steel Strip Ltd., of Tipton, a member of the Firth Cleveland Group, have concluded negotiations with the Steel Purchasing Organization of the German Democratic Republic for the supply of specified tonnages of their "Fircleve" brand hardened and tempered steel strip for a period covering several years. The form of agreement has been signed and exchanged between the two parties.

In order that their export commitments shall not interfere with the need to keep home trade customers supplied, Firth Cleveland Steel Strip Ltd. are embarking on an extensive programme of expansion; new hardening and tempering lines are now coming into operation, and others are planned at regular intervals over the next 12 months.

PLESSEY GAIN CONTRACT FOR AIRCRAFT ELECTRICAL SYSTEMS

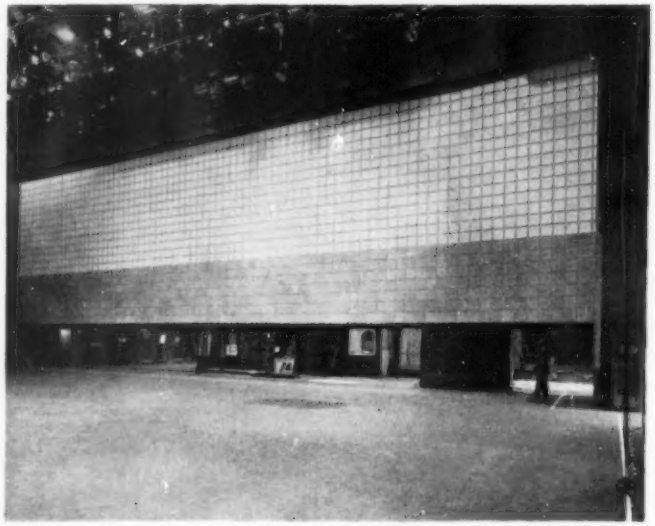
THE PLESSEY CO. LTD. announce that they have received a contract valued at £700,000 for the supply of aircraft generation systems for Vickers' latest jet airliner, the VC 10. The first 35 of these aircraft have been ordered by B.O.A.C. and delivery will start in 1963.

This contract follows a new licensing agreement that has now been concluded between Plessey and the Westinghouse Corporation, U.S.A., which allows Plessey to produce and market throughout the world—apart from U.S. territories and Canada—Westinghouse aircraft electrical generation systems.

This means that British-built equipment of advanced design and which is fully established in airline service is now available to British aircraft constructors.

SOUND-PROOF PARTITION WALL

A SOUND-PROOF partition, approximately 90 ft. long by 30 ft. high has been designed, built and erected by Geo. King Ltd., of Stevenage, Herts, at the Associated Rediffusion's Studio 5 at Wembley, the largest television studio in Europe, in order to divide the studio when normal productions, which do not require so much space, are in progress. The partition, which is claimed to be the largest of its kind in the world, comprises two leaves separated by a distance of approximately 6 ft. consisting basically of two thin-gauge steel sheets, one of which is "free" and the other, faced with absorbent acoustic material, integral with the main structure of the partition; the "free" leaf is faced with acoustic tiles. The two leaves are operated by two King lifting units, which incorporate Heenan and Froude dynamic coupling, powered by 4-h.p. motors driving through a Crofts reduction gearbox. These units effectually raise or lower the partition under corrected control in 30 minutes.



Books for Your Library

Symposium on Aluminium in Building. The Aluminium Development Association, 33, Grosvenor Street, London, W.1. 256 pp. £2 10s.

THIS book, which is profusely illustrated, partly in colour, is a report of the proceedings of the symposium held at the Royal Institute of British Architects on July 9 and 10, 1959, and comprises the final version of 13 papers, presented at three sessions, together with the discussion which followed each session. The symposium was convened in order to provide the opportunity for architects, builders and engineers to exchange ideas and information with the aluminium industry with the object to help forward the development of further new items by the aluminium industry and manufacturers. The report is in three divisions; Aluminium as a Building Material (three papers), Aluminium Curtain Walling (four papers) including surveys of curtain walling in this country, North America and Europe, and Aluminium Building Applications (six papers).

British Instruments. Second Edition. 1960. Scientific Instrument Manufacturers' Association of Great Britain, published by the United Science Press Ltd., Boswell House, Gough Square, Fleet Street, London, E.C.4. 635 pp. £2 5s. post free.

THIS is a combination of the "Instrument and Buyers' Guide," published by the United Trade Press, and "British Scientific Instruments," published by SIMA, which has resulted in the most comprehensive list of British scientific instrument manufacturers and their products yet compiled. Section 1 describes the associations allied to the instrument industry, Section 2 lists British Standards Specifications for scientific instruments and components, Section 3 contains an enlarged list of consultants, engineers and installers, and a more than three-fold increase of firms able to carry out development work and manufacture prototypes or small batches appears in Section 4. The classified list of instruments and components, Section 5, has been increased by 11 pages, and Section 8, indicating the number of new instruments manufactured, has been increased by 25 per cent. There has also been an increase of 12 pages in the manufacturers' reference sheets given in Section 9. It is proposed to distribute this Second Edition widely throughout the world.

Welding Handbook, Section III. American Welding Society, 33, West 39th Street, New York 18, New York. 512 pp., 335 illustrations, 78 tables. Price $9.0.

THE third section of the fourth edition of the Welding Handbook contains chapters on the following subjects: forge welding, thermit welding, induction welding, surfacing, metallizing, brazing, soldering, welding of plastics, adhesive bonding of metals, oxygen cutting, auxiliary oxygen cutting processes, arc cutting, ultrasonic welding, welding by cold working and stud welding.

Literature Surveys on Influence of Stress Concentrations at Elevated Temperatures and the Effect of Non-Steady Load and Temperature Conditions on the Creep of Metals. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., U.S.A. 108 pp. $4.50.

TO determine the state of knowledge in the field of stress concentrations and cyclic loading at elevated temperatures, the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals sponsored a two-part project designed to survey the published literature in this area. The result is this publication which brings into focus in a comprehensive fashion the tremendous amount of information available on these subjects.

The survey covering the effects of non-steady load and temperature conditions on creep of metals describes the fundamental investigations, summarizes data on alloys under complex variations of load and temperature, and reviews several analytical procedures for calculating non-steady behaviour from steady-state stress tests.

The survey on stress concentrations reviews the available notch-rupture data with the idea of establishing fundamental influences of stress concentrations, testing variables, and the influence of alloy compositions. Also included is a section dealing with the application of notch data to the problem of component design.

Extensive use has been made of graphs for presentation of data. Complete bibliographies are also included.

The material was gathered and prepared by W. F. Brown, Jr., S. S. Manson, G. Sachs and J. G. Sessler.

Recommended Practices for Gas-Shielded-Arc Welding of Aluminium and Aluminium Alloy Pipe. 1960. American Welding Society, Dept. T., 33 West 39th Street, New York 18, N.Y. $2, post free.

PREPARED by the A.W.S. Committee on Piping and Tubing, this 40-page booklet covers, in a condensed form, all phases of aluminium pipe welding, from processes and machine settings, to welding techniques and heat treatment. A conversion table recommends the filler metals to be used for welding different combinations of aluminium alloys and additional tables indicate the actual settings required for various pipe sizes and thicknesses.

A Glossary of Metalworking Terms, by H. Winfield. 1960. Blackie and Sons Ltd., 17, Stanhope Street, Glasgow, C.4. 80 pp. 5s.

THIS small handbook written by the lecturer in metalwork at St. Mary's College, Strawberry Hill, Twickenham, should appeal to students preparing for the G.C.E. examination in metalwork, for whom it was primarily prepared, since one of the difficulties to be overcome in learning a trade is the mastery of the language, which in metalwork is diverse since there are many crafts involved, each with their own traditional terms. The object of this handbook is to contain commonly used terms in various trades in one volume and where common terms are used in various trades with different meanings, these variations are given. There are also 17 line diagrams illustrating tools and equipment.

Finishing Line Equipment for a Heavy and Medium Plate Mill

SCHLOEMANN Aktiengesellschaft, Dusseldorf, is to supply the Forges de Clabecq S.A., Clabecq, Belgium, with the complete finishing line plant for a 9 ft. 4 in. heavy and medium plate mill. Included in the equipment is a hot leveller, rotary trimming shear, two rocking shears, roller tables, a cooling bed with plate turner, manipulators, pilers and scrap handling gear.

Scientists from 27 Countries to visit New York for Welding Conference

SCIENTISTS and engineers from 27 nations will visit New York City next April when the International Institute of Welding holds its assembly for the first time in the United States at the invitation of the American Welding Society. The world's top metallurgists, structural, design and mechanical engineers will be among those who will converge on New York to attend meetings and to exchange information on the latest developments in welding technology.

During the two-week period April 10-21, the following activities are planned: meetings of the executive and governing councils and the various commissions of I.I.W.; A.W.S. annual meeting at which 24 technical sessions will be held and 72 papers presented; A.W.S. welding show where over $3,000,000 worth of the latest welding equipment and materials will be displayed. The Sheraton Atlantic Hotel, Broadway and 34th Street, will be the headquarters hotel for the foreign deputations, and the Commodore Hotel, 42nd Street, the headquarters for the American Welding Society.

International Symposium on Metal Forming

THE Czechoslovak Scientific and Technical Society, Prague 1, Siroka 5, are to organize from September 13-20, 1960, concurrently with the Second Brno Trade Fair, an International Scientific and Technical Symposium which will be devoted to the forming of metals, especially forming at high speeds by extrusion, and the manufacture of press tools.

EFFLUENT AND WATER TREATMENT Exhibition and Convention

THE First Effluent and Water Treatment Exhibition and Convention is to be held at the Seymour Hall, London, from October 18-21. Delegates to the convention can register for £3 3s. which includes a set of 12 papers and entry to the exhibition. Three papers will be read—"Automatic *p*H and Redox Control in Cyanide and Chromate Effluent Treatment" by G. Mattock, "A New Outlook on Marine Water Treatment" by Ivor Raleigh, and "The Treatment of Waste Waters for Reclamation and Re-use" by V. E. Gripp.

Further details can be obtained from Thunderbird Enterprises Ltd. of 140, Cromwell Road, London, S.W.7.

INSTITUTE OF WELDING

THE 1960 Autumn Meeting of the Institute of Welding will be held between November 1 and 3, 1960, in London, and will be devoted to the metallurgy of welding and brazing.

The Annual Dinner of the Institute will be held on the evening of Thursday, November 3.

Accident Prevention Training Course

IN the autumn the Royal Society for the Prevention of Accidents (RoSPA) plans to hold a one-week residential safety training course for safety officers in the building and civil engineering industries.

The course will cover both theoretical and practical aspects of the work. In one study period, trainees will be asked to spot and correct faults in scaffolding under the expert guidance of Major D. K. Edwards of Scaffolding (Great Britain) Ltd.

The course will be held at the Civil Defence Staff College at Sunningdale, Berks, from November 13 to 18, 1960. The inclusive fee for the course will be £25.

All enquiries should be made to the Training Officer, Royal Society for the Prevention of Accidents, Industrial Safety Division, Artillery Mansions, 75, Victoria Street, London, S.W.1. (ABBey 6963/7.)

Iron and Steel Institute Symposium on Steels for Nuclear Reactors

CONTRIBUTIONS from Canada, the U.K., the U.S.A., and the U.S.S.R. are expected for a symposium on "Steels for Nuclear Reactor Power Circuits," being organized by The Iron and Steel Institute. The symposium will be divided into the following sessions:

Factors governing selection of steels; Fabrication aspects; Irradiation effects; High-temperature properties; Corrosion; Steels for future reactors.

The symposium will be held at the Hoare Memorial Hall, Church House, Great Smith Street, London, S.W.1, from November 30 to December 2, 1960. It will be included in the activities of the British Nuclear Energy Conference, of which The Iron and Steel Institute is a member.

Full details of the symposium will be announced later.

National Safety Awards

THE finalists in the National Safety Contest were recently presented with prizes valued at £1,000 at the Church House Restaurant, Westminster, by Mrs. Patricia McLaughlin, M.P. for Belfast West and secretary of the Parliamentary Home Safety Committee. The contest was sponsored by a number of leading firms and industrial organisations who each subscribed 200 guineas to run the campaign. The first prize of £500 went to Mr. S. W. Nobbs, a retired insurance official whose idea was that all cars should be manufactured with a sliding door. The second and third prizes, totalling £400, were shared by Mr. J. Bibby and Mr. K. R. Hall who both had the same basic idea that a metal shim should be inserted in the sole of all rubber boots to prevent nails and other sharp objects penetrating the foot.

Titanium Oxide Plant

CONSTRUCTION has started on the titanium oxide plant at Umbogintwini on the Natal Coast, South Africa, by South African Titan Products (Pty.) Ltd., a company formed by British Titan Products Co. Ltd. and African Explosives and Chemical Industries Ltd. The plant is expected to be completed by the beginning of 1962, will have a capacity of 10,000 tons per annum and will cost in the region of £3,000,000.

The contract for design, procurement and construction of the factory has been entrusted to W. J. Fraser and Co. Ltd. of Romford, Essex, and of Johannesburg, who will build in accordance with process designs and layouts supplied by South African Titan Products. A pipeline is being laid by Collins Submarine Pipelines Overseas Ltd., along the sea-bed to discharge the factory effluent a mile out to sea at a depth of some 110 ft.; this work is being undertaken with the assistance and co-operation of a Steering Committee set up by the Department of Water Affairs of the South African Government.

Publications for Industry

With the publication of the 1959 edition of the "Compilation ASTM Standards on Light Metals and Alloys," metallurgists and engineers will have available the latest materials standards in this area of technology. The book contains 57 standards, 15 of which are revised or have had their status changed since the previous edition. In addition it contains three new standards including one for aluminium alloy pipe for gas and oil transmission. A new specification for aluminium-coated steel wire for electrical transmission purposes and new method of test for electrical conductivity using eddy current procedures are also included.

In all, the book contains three recommended practices, 10 methods of test and 44 specifications covering such materials as aluminum and aluminum alloy, ingots, castings, bars, rods, wire shapes, forgings, pipe, tubes, sheet plate, filler metal and wrought products for electrical purposes. Magnesium and magnesium alloy ingots, castings, tubes, sheet, forgings, bars, rods, and shapes are also covered. In addition to general methods of test there is a standard for electroplating on aluminum alloys.

Copies of this book may be obtained from ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa. at $4.50 each.

* * *

"Confidence in Plating" issued by the Mond Nickel Co. Ltd. of Thames House, Millbank, London, S.W.1, is a 60-page booklet giving an account of a conference at the Engineering Centre, Birmingham, on February 23, 1960 and in the Queen's Hotel, Birmingham on February 24, 1960, concerned with the means of producing plating to meet the British Standard 1224:59 so that it can carry quality labels. There are eight sections, the first three of which deal with labelling, the British Standard and the value of specifications; section D describes the B.N.F. plating thickness gauge, sections E and F corrosion testing and the corrosion resistance of nickel-chromium plating, and sections G and H the care of plated parts and the effect of design on plateability.

The first in a new series of "Sifbronze Welding Data and Instruction Charts"—has just been published by The Suffolk Iron Foundry (1920) Ltd. This is a quick reference chart which gives, against all the commercial metals in general use listed in alphabetical order, the weld preparation details, melting point, filler rods, fluxing, flame setting, weld technique, and other important factors which are of interest to small welders.

Measuring 24 in. by 20 in., the chart is printed in two colours on stout card-paper which is suitable for mounting on plywood or hardboard.

The chart may be obtained from the Suffolk Iron Foundry (1920) Ltd., Stowmarket, Suffolk, for 1s. 6d. to cover the cost of packing and postage.

* * *

Imperial Chemical Industries Ltd., Imperial Chemical House, Millbank, London, S.W.1, have issued data sheets giving the properties of the first three of their "Silcoset" silicone rubbers, 100, 101 and 102, which can be cured at room temperature by the addition of one of two catalysts supplied with the product and the curing time varied to suit the needs of the user The rubbers are suitable for sealing, patching, caulking and potting applications, encapsulation of delicate electronic parts and moulds for casting resins and for low cost tooling.

* * *

Dust Control Processes Ltd., 161, Clarence Street, Kingston-upon-Thames, have issued a brochure describing a process for preventing the emission of corrosive and greasy black particles and the corrosion of flues and stacks in oil-fired installations. The system is to inject into the flue gases a controlled concentrate of finely divided alkaline hygroscope precipitate which absorbs acid and fine greasy particles into agglomerated particles which are then extracted from the gas stream by centrifugation. Three items of equipment are required, the "Insufflator" for injection of precipitate into the flue, the "Turbulator" to ensure mixing of the powder and gases, and the "Turbo cell Dust Collector."

* * *

F. J. Edwards Ltd., 359-361, Euston Road, London, N.W.1, have issued a pamphlet illustrating and giving full details of the range of cutting and embossing machines produced by J. Sandt AG, Pirmasens, Germany, for whom they are the U.K. agents.

The " Stabiliser," Vol. 27, No. 1, issued by the Lincoln Electric Co. Ltd. of Welwyn Garden City, Herts., contains an article "Automatic Horizontal/Vertical Welding for Nuclear Power Plant Construction" describing the successful operation of the Lincolnweld Universal Finewire Tractor Welder Unit in the works of the International Combustion Co. Ltd. of Derby.

* * *

The Production Engineering Research Association of Great Britain, Melton Mowbray, Leicestershire, have published a 16-page illustrated booklet—"Blanking and Piercing, Part II," previously circulated in duplicated form in May, 1954.

* * *

A six-page colour leaflet obtainable from The Aerograph-Devilbiss Co. Ltd., 47, Holborn Viaduct, London, E.C.1, presents in simple chart form the advantages to be gained by heating paint before spraying; these mainly are that the viscosity is reduced without the addition of thinners and a much higher percentage of solids is deposited on the article being sprayed.

* * *

The Wild-Barfield "Heat-Treatment Journal" for June, the official technical publication of the Wild-Barfield Electric Furnaces Ltd. and The Applied Heat Co. Ltd. of Otterspool Way, Watford By-Pass, Watford, Herts. and G.W.B. Furnaces Ltd. of Dudley, Worcs., includes an article on the principles behind electron beam heating for such materials as tungsten, tantulum, molybdenum, columbium and others which are hard to melt. It also contains a description of a new general-purpose induction-hardening machine which, unlike the usual design for specific operations, is claimed to be versatile in its applications.

* * *

Vol. 1, No. 4 of "Davy-United Engineering" issued by the Davy and United Engineering Co. Ltd. of Darnall Works, Sheffield 9, is devoted entirely to an article on strip mills 42 in. in width and above. Davy and United have also published an illustrated broadsheet describing the varied activities of the Group as well as a small brochure intended for the use of visitors to Durgapur, explaining Davy-United's place in the British Consortium, ISCON, which is building the Durgapur Steelworks. Davy-United's commitment in the latter project totals around £29 million and includes over 70,000 tons of equipment.

ALUMINIUM BODIED TIPPERS

THE Northern Aluminium Co. Ltd. of Banbury, Oxfordshire, have reported the recent construction of aluminium tipper and dump truck bodies in which the use of aluminium has resulted in a considerable saving in the weight of the vehicle and consequent increase in load carrying capacity. One such vehicle is an all-welded aluminium alloy tipper completed by Amalgamated Roadstone Corporation Ltd. at their Metalair Works, Wokingham, and designed for carrying granite chippings; the body weighs only 12½ cwt., which is a saving in weight of 1½ tons, and has a capacity of 16 cubic yards, giving it a payload of 16¼ tons. As much as 3 cwts. may have been saved by adopting welded instead of riveted construction. The vehicle has a Foden 8-wheeled chassis and the body is of welded U-shape, the flat floor being a single piece of B.S. 1477, NP5/6 aluminium alloy plate ¼-in. thick with sides of 8 s.w.g. (0.16 in.) alloy sheet to the B.S. 1470; NS5 specification, formed at the bottom to a 10-in. radius; the tipping sub-frame is made up of two full-length longitudinals formed from ¾-in. NP5/6 plate. The aluminium alloys were supplied by the Northern Aluminium Co. Ltd. and the welding carried out by the use of Argonaut equipment supplied by the British Oxygen Co. Ltd.

Another vehicle is a heavy duty dump truck designed and constructed by the Plymouth bodybuilding firm of Drake Motors Ltd. for the Newton Abbot haulage contractors, W. L. Vallance Ltd. who are using the truck for excavation and demolition work. The chassis is an A.E.C. six-wheeled Mammoth Major "Dumptruk" with twin-articulated rear axles and the tipping body was constructed from aluminium sheet and extrusion in Noral B51SWP alloy supplied by Northern Aluminium Co. Ltd.

Aluminium "Dumptruk" built by Drake Motors

The unladen weight is 3 tons 7 cwt. less than a similar vehicle with a steel body and the body has a cubic capacity of 11½ cu. yd. to the top and sides and 12½ cu. yd. to the top of the raves.

NEW BRITISH SCIENCE EXPORT

ORDERS are being received at the rate of one a month—£200,000 a year—from home and overseas for the X-ray scanning microanalyser developed by the Tube Investments Research Laboratories in collaboration with the Cavendish Laboratory at Cambridge, and now being manufactured and marketed by the Cambridge Instrument Company.

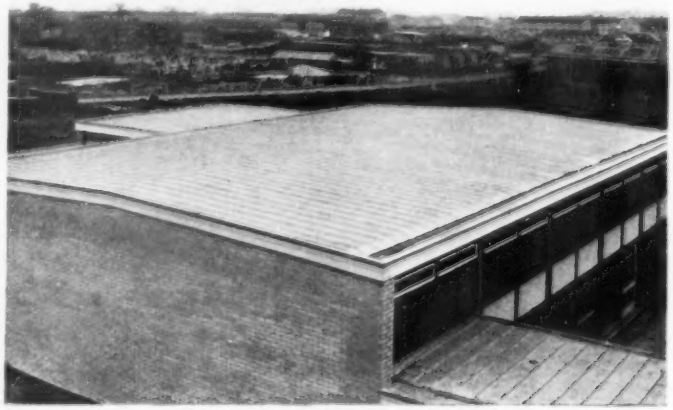
Deliveries have begun. Three instruments will be exported to the United States during this year.

This specialized instrument provides a qualitative and quantitative metallurgical analysis of a sample by irradiating and scanning the sample under investigation with a fine beam of electrons, and analysing the resulting emission of X-rays. The X-ray image is displayed on one of two cathode ray tubes. The other tube simultaneously displays a reflection electron image of the same area. Thus a direct visual comparison between the surface topography of the specimen and the distribution of a selected element can easily be made.

The microanalyser has wide and growing research and industrial applications.

ALL-ALUMINIUM ROOFING

ALSTRIP aluminium roofing system at Beanfield Junior School, Corby, Northants, manufactured by Verity and Gardiner Ltd. of Northampton from 22 s.w.g., Noral 2S½H aluminium alloy sheet supplied by Northern Aluminium Co. Ltd. The school was constructed for Northamptonshire County Education Committee to the design of the County Architect Mr. A. N. Harris, F.R.I.B.A., the main contractor being Drabble Construction Ltd., Wellingborough, Northants.



SIR GEORGE EARLE SAFETY AWARD

THE Sir George Earle Trophy for industrial safety achievement has been awarded this year to Associated Electrical Industries (Manchester), Ltd. (formerly Metropolitan-Vickers Electric Co. Ltd.).

The Royal Society for the Prevention of Accidents states that the trophy has been awarded "in recognition of very many years of outstandingly successful efforts to produce a safe place of work for its large number of employees through training, both general and specific, given to all branches of personnel, by the meticulous guarding of hazardous plant and machinery, and in recognition of the generosity of the company in making its help and advice readily available to others in the interests of accident prevention."

An accident prevention committee has been part of the company's safety organization for 34 years. Particular attention has been paid to the training of personnel employed and from their first day in the works apprentices of all grades are given safety training, which is continued throughout the whole of their apprenticeship.

During the past 12 years the company's frequency rate for reportable accidents has fallen from 1.13 to 0.46.

OIL PIPELINE IN BORNEO BUILT BY BRITISH FIRMS

A NUMBER of British firms are playing a part in the construction of a 160-mile pipeline that is to run from the Tandjoeng oilfields in South-east Borneo to the port of Balik Papan. The pipeline is being built for De Bataafsche Internationale Petroleum Maatschappij, N.V., of The Hague, on behalf of the Royal Dutch Shell Group.

Construction of the pipeline is being undertaken by William Bros. and Constructors John Brown Ltd., of London. Equipment to be used includes SAE 300 diesel engine-driven welding units supplied by the Lincoln Electric Co. Ltd., and cylinder fittings and gauges manufactured by British Industrial Gases Ltd.

Construction of the pipeline, which is of 20-in. diameter, will be completed in about two years' time.

ELECTRIC DRIVE FOR NEW ROD MILL

AN order worth about £700,000 for electrical equipment for a new rod mill has been obtained by the Heavy Plant Division of Associated Electrical Industries Ltd., from the Broken Hill Proprietary Co. Ltd., Australia. The mill will be driven by direct current motors ranging in output from 600 to 2,500-h.p., and the total power available will be 17,700 h.p. Mercury-arc rectifiers, rated in all at 13,000 kW, will supply the mill motors. Switchgear, control gear, auxiliary drives, and other equipment are included in the order.

Most of the electric control equipment required will be manufactured in Australia by Australian Electrical Industries (Proprietary) Ltd. Responsibility for manufacturing the rest of the equipment will be divided between the Rugby and Manchester (Trafford Park) works of A.I.E.

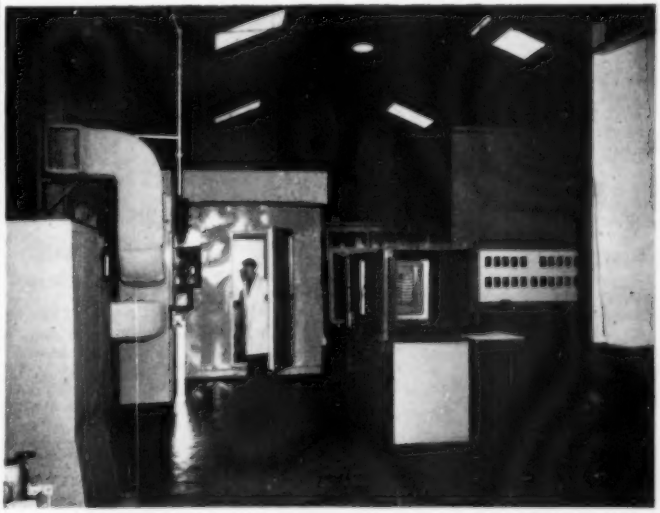
SOLID WHEEL AND WHEEL DISC MILL

A PLANT for the manufacture of solid wheels and wheel discs, recently erected in Japan, has been supplied by Schloemann Aktiengesellschaft, Düsseldorf, with a 3,000/6,000/9,000-ton die-forging press and a rolling mill having a guide roller system (DB patent) developed by Schloemann. The guide rollers provide a three-point bearing for the wheel and hold it in the vertical position during the rolling operation. This means that unpierced blanks can be worked without using a mandrel.

Material handling and transfer equipment links the individual production units, the workpiece being mechanically conveyed throughout the entire manufacturing process, from the delivery of the billet to the off-loading of the finished wheel. The operating speeds at which the material is dealt with on the belt conveyors and bogies, and by the tilters, loading and centring devices, are co-ordinated to suit the work cycle of the plant as a whole.

BRITAIN'S LARGEST SPACE HEATING RESEARCH LABORATORY

COPPERAD LTD., heating and ventilating engineers, have recently opened Britain's largest space heating research laboratory at Colnbrook, Bucks. The laboratory carries out work on a very wide range of subjects, including, in addition to the various aspects of heating and ventilating, the durability of paint used on the company's products and the evaluation of rubber foam, plastics and adhesives. The climatic room used for testing fan coolers and fan convectors can simulate temperature and humidity conditions occurring anywhere in the world. A Bonecourt gas-fired steam boiler used for supplying steam and hot water for testing equipment is rated at 500 lb./hr. at 200 lb. per sq. in., will heat water up to 380° F. and supplies the Copperad Raystrip and Wallstrip which heat the building.



NEW TECHNIQUES FOR MACHINE TOOL PERFORMANCE

WITH the collaboration of industrial firms, two techniques developed at the National Physical Laboratory and the National Engineering Laboratory are being applied to improve the performance of machine tools. One is the optical method of measurement and control using moire fringes and the other is a simple, cheap hydrostatic transmission for machine tool drives. Both these techniques have been demonstrated by the Department of Scientific and Industrial Research at the International Machine Tool Exhibition at Olympia. A booklet "Moire fringes for measurement and control" has been circulated to the machine tool industry and copies can be obtained from D.S.I.R., 5 to 11, Regent Street, London, S.W.1.

International Fluid Power Conference Scheduled For 1962

THE next international conference, to be organized by the journal "Compressed Air and Hydraulics," will be convened in April, 1962. It will follow as a logical development from the Second European Fluid Power Conference which was held in April at Olympia, London, and which was attended by delegates from 37 countries from all five continents. In view of the desire for knowledge of the many applications of fluid power which exists among engineers, the third conference will be even more ambitious in character and presentation.

Detailed plans cannot yet be announced but the following general information indicates its scope.

1. A specially soundproofed hall, with interpreting facilities, will be built in Olympia.

2. There will be a panel of arbitrators, drawn from industry and Government research departments who will ensure that the standard of the papers is at the highest possible level.

3. There will be two distinct types of session: highly technical advanced papers of prime interest to manufacturers in the fluid power industry, and also manufacturer-user discussion sessions.

4. The duration of the Conference will be five days.

The panel of arbitrators will be announced after discussions have taken place with the associations and societies which represent the fluid power industry.

REED BROS. OBTAIN SELLING RIGHTS FOR U.S.A. LOMBARD MACHINES

REED BROTHERS (ENGINEERING) LTD. of Woolwich, London, have recently concluded a manufacturing and sales agreement with the Lombard Corporation of Youngstoun, Ohio, and D. L. Lombard and Sons Engineering Ltd. of London, which gives Reed Brothers the sole manufacturing and selling rights in the United Kingdom for the Lombard mechanical and hydraulic drawbenches, which in future will be known as "Reed-Lombard." These drawbenches, for the reduction of steel and non-ferrous products, embody many unique design features, protected by patent, and incorporate facilities to draw 1, 2, 3, 4 or 5 tubes at one time.

ALFRED BULLOWS OPEN BRANCH IN AUSTRALIA

ALFRED BULLOWS AND SONS LTD., Long Street, Walsall, Staffs announce that they have established a subsidiary company in Australia, known as Alfred Bullows and Sons (Aust) Pty. Ltd. Ethel Avenue, Brookvale, Sydney, N.S.W.

This subsidiary company is able to offer the full range of Bullows equipment including "Hydrovane" air compressors, spray guns, spray painting equipment, and the latest development, the "Nopump" spray booth.

Under the management of Mr. W. J. Proffitt, this new company is able to give a high standard of service to its Australian customers.

CHANGES OF ADDRESS

THE Cambridge Instrument Company Ltd. announces that its Nottingham Office (Resident Engineer—Mr. H. G. Starling), will operate from larger and more convenient offices. The new address is as follows: Cambridge Instrument Company Ltd., Century Insurance Building, Milton Street, Nottingham (Telephone: 42612).

PRECISION COMPONENTS (BARNET) LTD., makers of polythene bowls, buckets and bins, have changed their address to Kabi Works, Cranborne Road, Potters Bar, Middlesex.

ASSOCIATED ELECTRICAL INDUSTRIES LTD. have moved their London Press Centre from 33, Grosvenor Place, London, S.W.1 to Crown House, Aldwych, London, W.C.2. The new telephone number is Temple Bar 8040. The initial members will be Stanley White, with J. F. Amor and G. A. T. Burdett representing the Manchester and Rugby interests.

THE Tate Machine Tool Co. Ltd., sole U.K. agents and distributors of the Müller mechanical power presses 8 to 500 tons capacities, have secured larger premises at 348-354, Kensington High Street, W.14. Part of these premises are being used as a showroom.

THE AEI Midland Regional Office in Birmingham is now at Associated Electrical Industries Ltd., Gloucester House, 65 Smallbrook, Ringway, Birmingham, 5. Telephone Nos: Midland 6335 and Midland 9551.

The special sales offices of AEI-Birlec Ltd., AEI Lamp and Lighting Co. Ltd., AEI Sound Equipment Ltd., the Cable Division, Radio and Electronic Components Division, and Telecommunications Division, as well as Siemens Ediswan Lamps and Lighting, the X-Ray Service Department, and the Construction and Erection Departments remain at their present addresses.

Dowding and Doll Obtain Further Order from Russia

DOWDING AND DOLL LTD., 346, Kensington High Street, London, W.14, have received an order for a further ten model V.8 universal gear hobbing machines valued at over £27,000 from the U.S.S.R. This is the third order for hobbers this company has received from Russia this year, bringing the total to 56 machines valued at over £136,000.

CHANGE OF NAME

THE Salem Engineering Co. Ltd. of Milford House, Milford, near Derby, have changed their name, to Salem-Brosius (England) Ltd. There is no change in the management of the company nor in the board of directors and the change of name is only intended to indicate the close relationship of the company with Salem-Brosius Inc. of Pittsburgh, U.S.A., and its associated companies.

New Plant and Equipment

High Tractive Power Monorail Hoist-Tractor

LOADS of 13,000 pounds can be pulled at speeds up to 60 ft. per min. with a "hoist-tractor" introduced by Harnischfeger Corp. of 4444 W. National Ave., Milwaukee 46, Wis., U.S.A. The "P and H Pull-a-Hoist," which is shown encircled in Fig. 1 is designed to power any make of hoist along any standard "I" beam or wide flange beam; it is easily installed, weighs only 83 lb., requires 12 in. of headroom and uses only 13 in. of rail space for "end approach." Special operating features include oil-smooth adjustable torque brake and a special "soft-start" motor which minimizes any tendency of load jerking; immediate tractive response to power is assured by a solid neoprene-tyred drive wheel under positive adjustable spring pressure, which is said to be more efficient than the conventional pneumatic-tyred wheel. The unit is available with single or two-speeds, separate push-button controls or with integrated hoist-and-tractor control; the standard model is single speed, 220v., three-phase, 60-cycle; options range from 110v. to 550v. and 50-cycle instead of 60-cycle.

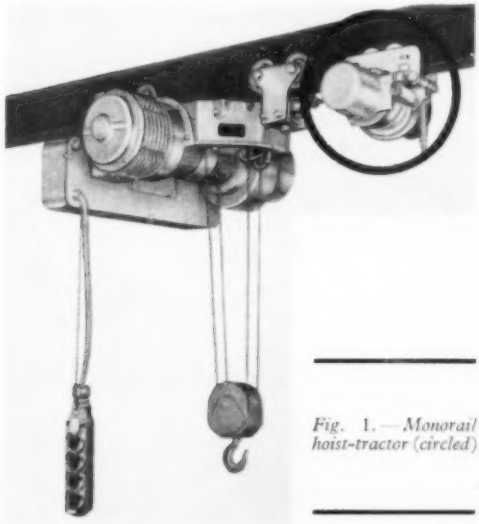


Fig. 1.—Monorail hoist-tractor (circled)

Precision Bandsawing and Bandfiling Machine

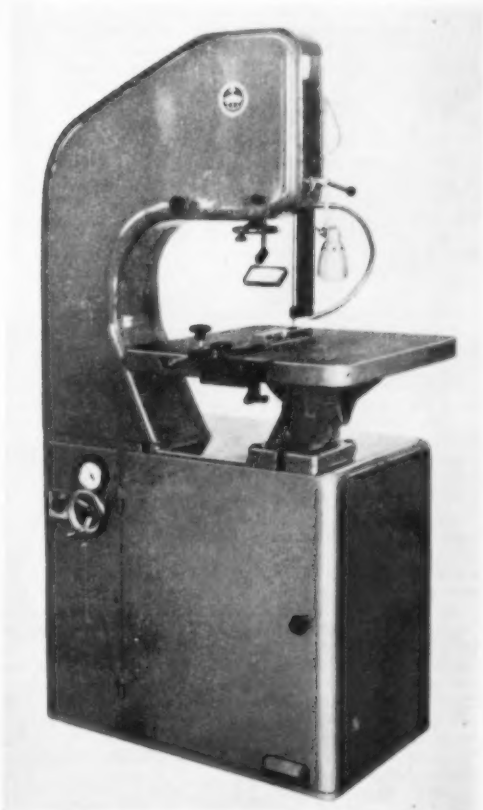
GEBR. THIEL, Western Germany, for whom sole selling agents in the United Kingdom are Rockwell Machine Tool Co. Ltd., Welsh Harp, Edgware Road, London, N.W.2, have recently introduced a precision bandsawing and bandfiling machine. The model, Thiel 117, shown in Fig. 2, incorporates three saw guide wheels mounted on shielded ball bearings, allowing a deep throat of 19¾ in. The front upper wheel is mounted on a block which is adjustable in its guideways by an external handwheel for correct tensioning. Large hinged doors provide access to the saw wheels and allow quick saw changing.

The machine is powered by a 1½-h.p. motor mounted in the base and controlled by a foot-operated switch. Drive is by a variable-speed unit providing saw speeds infinitely variable from 50 to 3,000 ft. per min. Speed is changed by the handwheel at the left of the base, the adjacent dial indicating the set speed.

The 24-in. × 24-in. table is mounted on a trunnion bracket which allows table swivel up to 30 deg. to right and left and up to 15 deg. to front and back. Swivelling movements are by rack and pinion, graduated scales indicating the angle of inclination. The upper and lower precision saw guides are adjustable for height, the maximum thickness of work admitted being 9¾ in. A magnifying glass and low-voltage work light, both on adjustable mountings, are included in the standard equipment as is the air pump and piping for swarf dispersal. A chute within the machine frame delivers swarf to the front of the base.

A bandsaw butt welding and annealing unit is housed beneath the upper hinged door and includes a grinding wheel and guillotine. The drive sprockets and special guides for bandfiling are easily and quickly fitted. It is unnecessary to remove the bandfile drive sprockets when using the machine for bandsawing.

Fig. 2.—Bandsawing and bandfiling machine



Three Position Ventilator

COLT VENTILATION LTD. of Surbiton, Surrey, have produced the O/S.R. ventilator which is operated by a simple cord control and can be used in three positions—wide open giving maximum extraction in hot summer conditions, with the top flaps resting on stops giving complete weathering for normal conditions, and with the flaps dropped to completely seal the ventilator.

Open-gap Pneumatic Press

AN interesting machine on show at the private exhibition of Henry Pels continental machine tools, was the Burger open-gap pneumatic press (Fig. 3). It represents a new and patented press design, which allows a claimed economical performance in many press-work operations. The machine has a sturdy cast-iron body with all moving parts hardened and ground. The press table can be adjusted in height by means of a handwheel and is also made of cast iron, with a centre hole for ejection. The dimensions of the table have been selected on the large side and coupled with the diagonal T-slots, permit any type of clamping. The drive is actuated *via* the pneumatic piston and a lever system to a knee lever which in turn actuates the press plunger. Comparatively high pressures can be obtained using this system.

The stroke, normally 1 to 1½ in., can be adjusted from 0 to 1½ in. by means of a rapid setting device. This is done first by a coarse setting device in steps of ¼ in. The dimensions of the compressed air cylinders are such that the air consumption is kept low. The maximum ram pressure of 7 tons is attained by means of the lever system and the knee lever at an operating pressure of 90 p.s.i. A built-on pressure reduction valve with water control and noise absorber, enables the machine to be adjusted at any time to the required operating pressure, and works silently without the disturbing air escape noises.

Another machine that had considerable attention paid to it at the exhibition, was a recent development of an earlier transfer press (Fig. 4), made by Contruzioni Meccaniche Benelli Gavazzi Firenze. The aim here has been to keep the design on simple lines and provide a greater variety of processing on one machine, allowing the economic use of the press for small quantities of components.

The ram reciprocates on four large diameter pillars and is driven from the crankshaft by one, two or four rods according to requirements. Transfer of components takes place by means of fingers opening and shutting by cam control from the ram and deriving their index motion from the crankshaft rotation in a continuous circular path. It has two side-located blank and draw stations, two feeding stations for the strip and staggered feeding if required. The press is controlled from a mobile instrument panel consisting of the main switch for inching, single stroke operating and continuous running.

The main advantages claimed for this press are that by reason of the concentric layout, there is a possibility of containing the pressure within a smaller compact area, avoiding unbalance and permitting installation of a greater number of tools. The transfer of components from one station to another also has the advantage of being rotary, no part of the cycle being used to reverse the transfer fingers, as in the case of a lineal press. This method of transfer gives access to the workpiece for the inclusion of rotary type tooling in the operation sequence. Another advantage claimed is that the machine will work two different workpieces at the same time using different materials. Enquiries for either of these machines should be made to Henry Pels and Co. Ltd., 32-38, Osnaburgh Street, London, N.W.1.

(*Continued in page* 710)

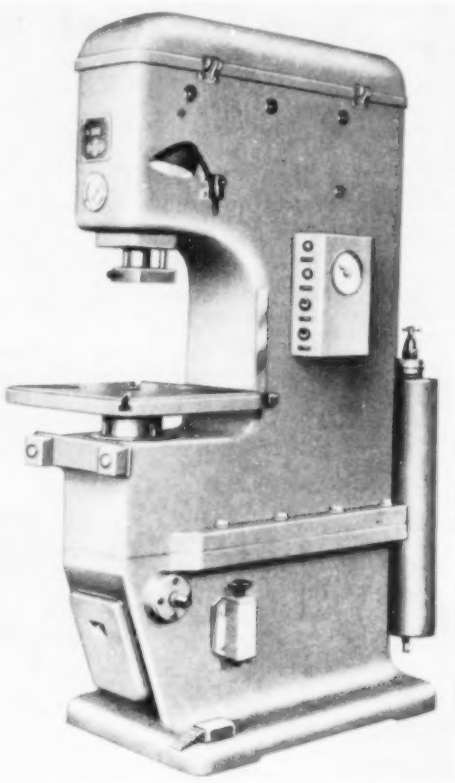
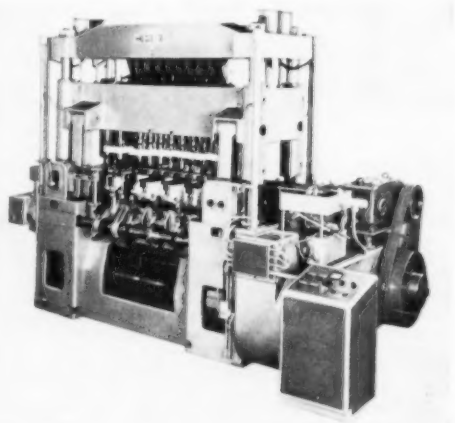
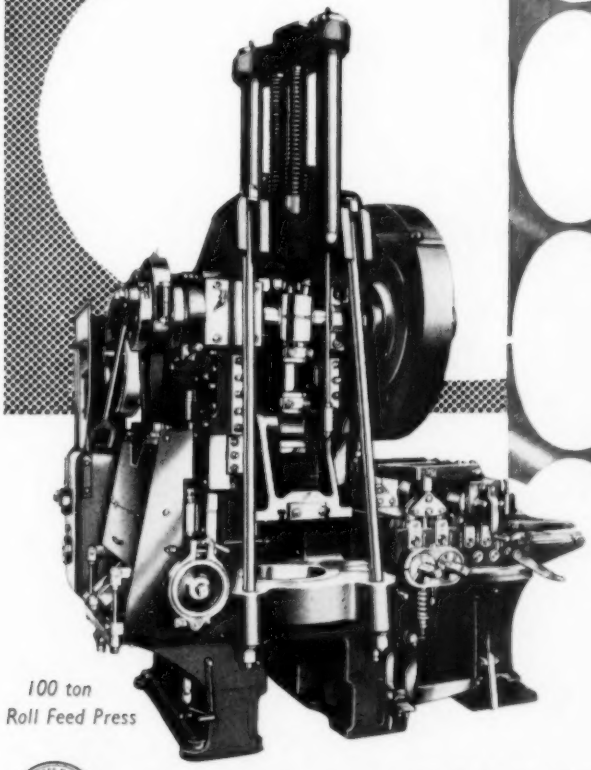


Fig. 3 *(above).—Open-gap pneumatic press*

Fig. 4 *(below).—Transfer press*



AUTOMATIC FEED PRESSES



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Hydrostatic Spray Plant

FIG. 5 illustrates the Model 226-066 stationary hydra-spray produced by Alfred Bullows and Sons Ltd., Logn Street, Walsall, which operates direct from 44-gallon open-top shipping drums and is skid mounted for ease of movement. High operating pressures of 1,000 to 3,000 lb. per sq. in. are achieved by the use of a reciprocating double-acting air motor coupled to 20:1 ratio reciprocating double-acting pump, which together with an air-operated paint agitator, air inlet pressure reducing valve etc. is mounted on the drum head. An air-operated elevator is also provided to facilitate changing the drum.

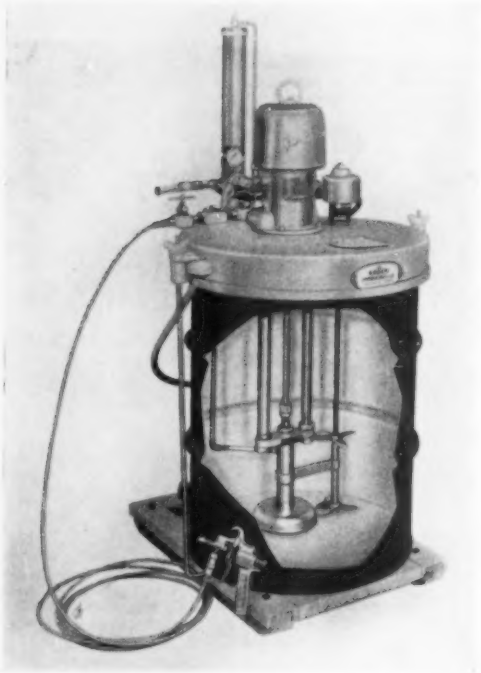


Fig. 5.—Stationary hydrostatic spray

Swivel Handle Pliers

A NOVEL pair of pliers has been introduced to facilitate access to components in difficult places. The jaws can be swivelled through a full 360 deg. and locked at an angle to the handle; indexed locking positions are provided at each 45 deg. Removal of the locking screw allows the jaws to be removed and replaced by a different pair, and pairs of jaws designed for a variety of purposes are available. The tool is manufactured in Western Germany, and is available from O. Winter (Technical Agencies) Ltd., 8, Priory Mansions, Priory Park Road, London, N.W.6.

Light-duty Air-operated Press

SCAN-TECHNIC LTD. of Denmark, have recently introduced into this country a compact air-operated press for light engineering work, designed to replace fly presses and to free large expensive presses for more appropriate work; uses for the "Hydromatic" include pressing, riveting, broaching, forming, assembling, punching, cutting, marking, imprinting, embossing, the assembly of fragile components and the stamping and coining of hard materials; the machine shown in Fig. 6 is equipped with automatic foil feeding and is used for embossing and imprinting lettering and trade marks on plastic bottles and jars, but can be used for similar work on other materials.

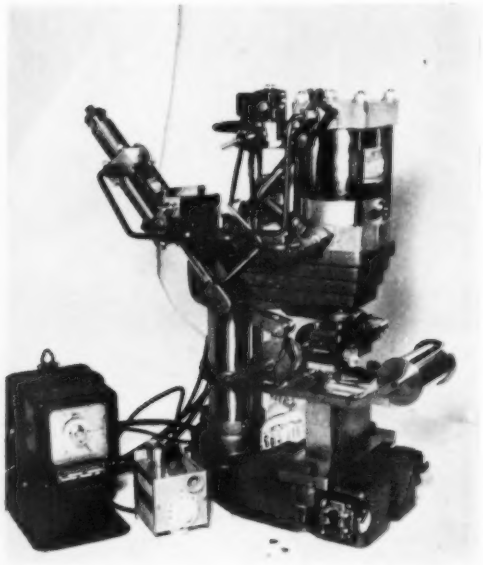
Two or more operations can be combined into a single process synchronized with automatic work feeding, clamping, ejection and chip dispersal. The unit is equipped with an electro-magnetic timer and remote control so that it can be used as a fully automatic one-man plant or alternatively a battery of presses can be installed to produce a number of articles under automatic or semi-automatic conditions.

The rated ram force is constant throughout the stroke, no bottom stroke being required; the length of stroke is variable up to 20-in. and the working gauge pressures range from 15-176 lb. per sq. in. Three power types are available—single acting with maximum-force down-stroke, return stroke by internal spring; double action with maximum-force both ways; single or double acting with through-going piston rod. Three types of speed control can be provided—variable speed control ensuring smooth even travel throughout the downstroke with forced return or forced downstroke or a combination of these; adjustable air cushion for braking the last 20 to 40 mm. of the downstroke, return stroke or both ways; a combination of both these types.

The U.K. agents are Park Regency Ltd., 60, St. Paul's Churchyard, London, E.C.3.

(*Continued in page* 712)

Fig. 6.—Air-operated embossing press



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Mobile Airless Spray Plant

FIG. 7 shows an airless spray painting plant produced by Aerograph-DeVilbiss Co. Ltd., 47, Holborn Viaduct, London, E.C.1, designed for large products that cannot be placed in spray booths. The plant will spray a very wide range of materials by fluid pressure alone, (without atomization, air, heat or multiple hose lines) at very high viscosities and enables a thick film to be built up for good protection with few coats. The equipment consists of a 24:1 ratio pump mounted on a pneumatic-tyred hand truck which is fitted with a paint agitator, air lift, air pressure regulator and a 10-gal. container (into which a 5-gal. paint drum may be placed); a heavy-duty spray gun with tungsten carbide spray cap; stainless-steel wire braid reinforced high-pressure material hose; and a heavy-duty air supply hose. The agitator mixes the paint and keeps it in proper suspension and the air lift enables containers to be changed over rapidly and easily; the air pressure regulator controls material pressure for ideal atomization.

Fig. 7.—Airless mobile spray plant

Gas-bottle Holder

THE Argosy Tubular Products Ltd. of Argosy Works, Hertford Road, Barking, Essex, have produced the Argosy gas-bottle holder designed for holding bottles with round bottoms. The holders are suitable for 180 cu. ft. bottles, are 29 in. high and the base of 21½ in dia. enables bottles to be stood upright with safety.

Self-drilling Concrete Anchors

PHILLIPS DRILL CO. of Michigan City, Indiana, U.S.A., whose London office is at 10, Union Court, Old Broad Street, E.C.2, have introduced in this country for the first time their "Red Head" self-drilling permanent concrete anchor system. The "Red Head" is a carbo-nitrite heat-treated hollow core steel expansion shell which quickly cuts its own close-fitting hole into the toughest concrete without spalling and can be used with either a percussive hammer or by hand. When the hole has been drilled, the "Red Head" can be used as an anchor by inserting a cone-shaped plug of hardened steel into the cutting end and reinstalling it into the hole by the same means as the drilling process; this has the effect of expanding the cutting end and undercutting the hole to give a fully dove-tailed anchor in which self-cutting annular broaching grooves act as additional grips into the concrete, brick or stone, in which it is used. The anchors are provided with class 2 U.S. standard or Whitworth internal threads to accommodate bolts or screws and are available in a wide range of sizes and types to suit most wall, floor or ceiling fastenings.

Silicone Grease

A SILICONE grease, M.494, has been added to the rapidly growing range of ICI Nobel Division silicone products. The outstanding electrical qualities of M.494, coupled with the silicone characteristic of intense water-repellency, give it high efficiency as a sealing agent for electrical equipment, and as a general agent to protect surfaces against moisture.

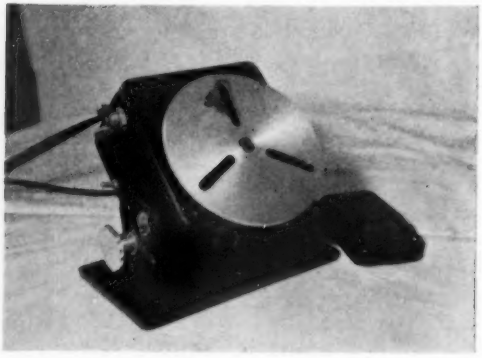
Further particulars about M.494 and other members of the I.C.I. range of silicone greases, M.490, DP.49 and DP.203 will be supplied from the nearest I.C.I. Sales Office or from I.C.I. Ltd., Nobel Division, Silicones Department, Stevenston, Ayrshire.

Bench Model Welding Turntable

THE "Aircrafter Bench Model Turntable" shown in Fig. 8 has been developed by the Superior Welding Co., 3410 East 14th Street, Los Angeles 23, California, U.S.A. It is designed to hold work in any position from horizontal to vertical. It provides a smooth stepless speed change both forward and reverse from zero to 7 r.p.m. or a greater speed ratio by a gear change. The turntable weighs only 20 lb. and can carry a 100 lb. load; the table is 7 in. in diameter and speed is set by a rheostat with a foot control switch for "on and off" or ratio control.

(*Continued in page* 714)

Fig. 8.—Bench model welding turntable



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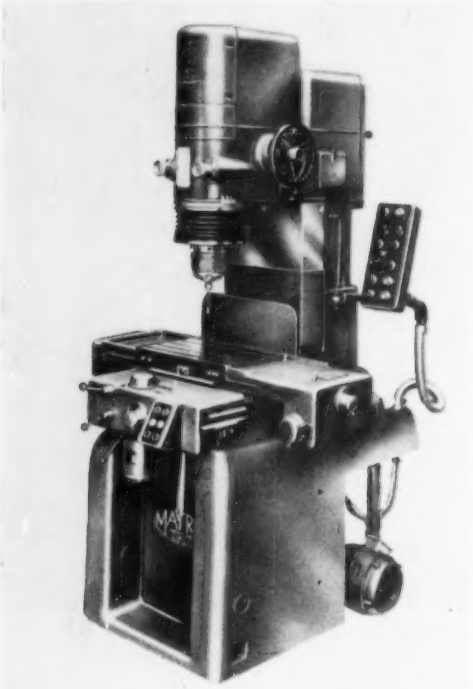
Jig-grinding Machine

THE "Matrix" 56-12-18 Jig Grinding Machine shown in Fig. 9 is a British designed and built machine produced by the Coventry Gauge and Tool Co. Ltd., the sole agents in the United Kingdom for whom are the Rockwell Machine Tool Co., Welsh Harp, Edgware Road, London, N.W.2. This machine is said to enable hardened materials to be worked without distortion and held to close tolerances, thus overcoming the problems of maintaining tolerances when hardening finished parts.

Fig. 9.—Jig-grinding machine



Corrosion Deterrent

THE Plus-Gas Co. Ltd., 1 to 11, Hay Hill, London, W.1 have produced a solution for the pre-treatment of rusted metal surfaces before painting—Formula "E," a non-acid, non-toxic fluid, made from a special blend of tannins, which combine with the oxides on already corroded metals (ferrous or non-ferrous) to form a hard and insoluble tannate film. This film halts further corrosion by making the metal inert and at the same time creating a surface which bonds well with all recognised industrial paints and increases their covering capacity. The solution is claimed to be safer and easier to use than phosphate or phosphoric acid compounds, as well as being cheaper and can be of assistance in welding and flame cutting operations since lightly corroded plates can be resistance welded after treatment with the fluid and an oxyacetylene flame will burn away the film without leaving any slag deposits.

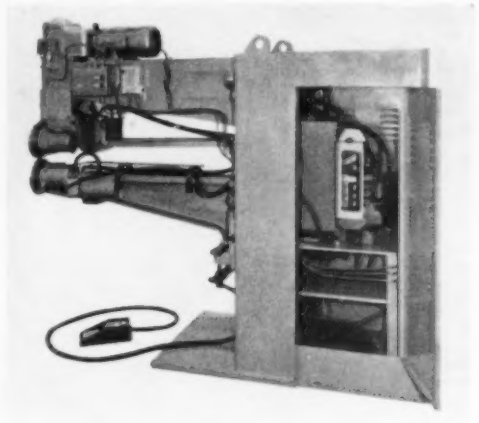


Fig. 10.—Seam-welding machine

Roll Seam-welding Machine

THE "SAGU 125" air-operated universal roll-seam welder, being produced in this country by Electro Mechan-Heat Ltd. of Kingston-upon-Thames, is designed for the mass-production of drums and tanks or the fabrication of sheet-metal sections such as are required in the construction of railway carriages (Fig. 10). The motor is sited on top of the upper arm and the drive transmitted by a vertical shaft and gearing through the air cylinder and welding head of the upper electrode. The machine can be used for circumferential or longitudinal seam welding by simply rotating the upper head through 90 deg. in either direction and exchanging the lower arm extension; circumferential welds can be made clockwise or anti-clockwise as required by operating a reversing switch; the vertical shaft is driven by a 3-phase KOPP variable-speed motor developing 0.5 h.p. at 1,000 r.p.m. which can be set by means of a variator to run at speeds between 310 and 2,800 r.p.m. to give lineal feed rates of 1 ft. 11 in. per min. to 21 ft. 6 in. per min. between electrodes.

Crystal Chronometer

COMMUNICATIONS SYSTEMS LTD., Norfolk Street, London, W.C.2, have developed an all-electronic precision pulse source with a time interval accuracy of the order of a few seconds per annum, contained within a small physical unit and employing a crystal-controlled oscillator to generate a basic frequency which is fed to a series of binary dividers. The outputs of the dividers are fed to separate pulsing relay circuits to produce pulses at required intervals. Circuits are completely transistorized and make use of printed circuit panels of the plug-in type. The standard chronometer operates on 24 volts d.c. and produces three square wave pulses at intervals of 1, 30 and 60 seconds respectively, but other pulse outputs can be provided.

Anti-splatter Welding Compound

THE Union Carbide International Co., 270 Park Avenue, New York, 17, have produced a silicone-containing compound called "65 Sigma Nozzle Compound" which eliminates work stoppages caused by splatter encrusting welding nozzles. The compound is applied to the nozzle before welding and forms a thin invisible coating over the bore and mouth preventing the splatter from sticking.

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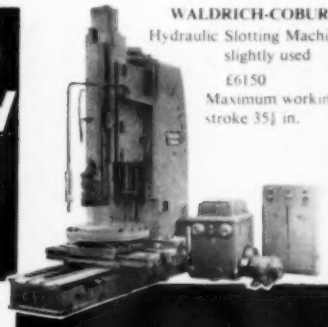

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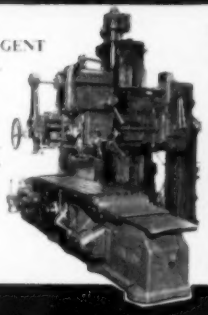

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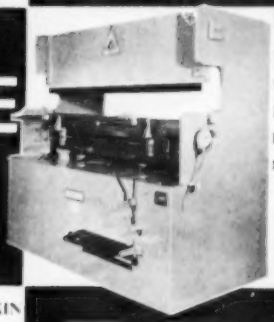

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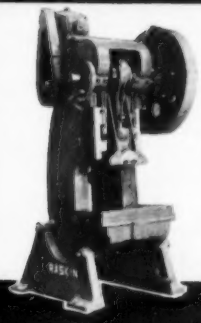

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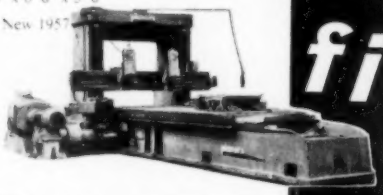

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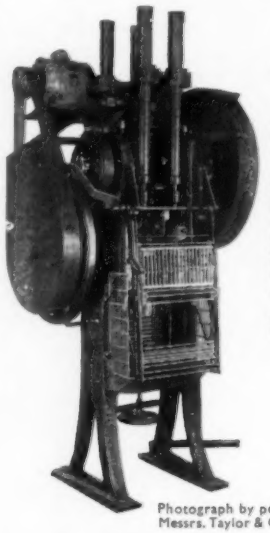

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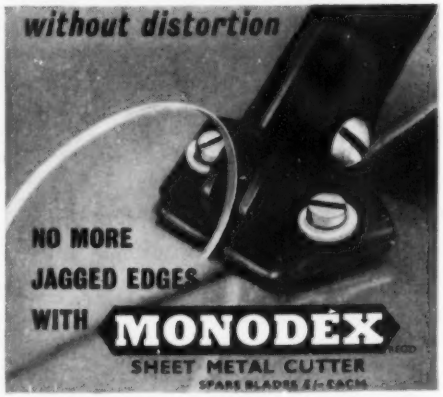

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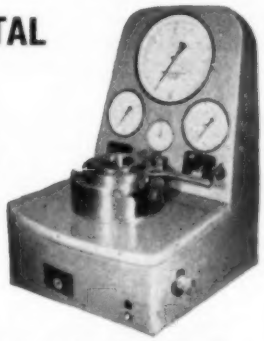

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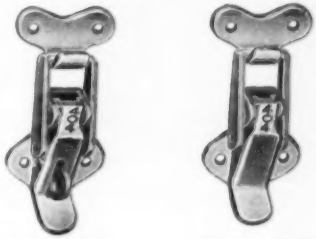

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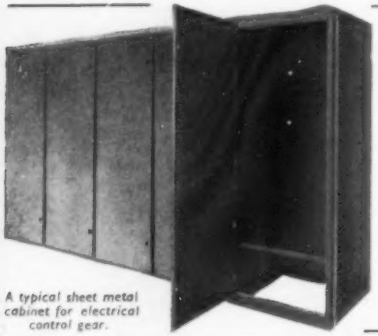

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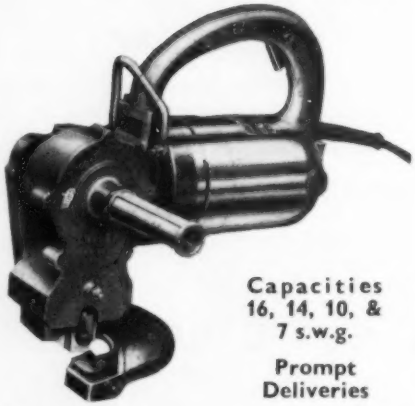

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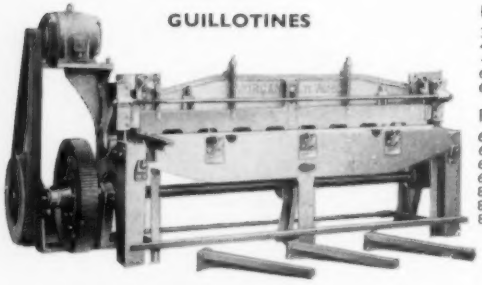

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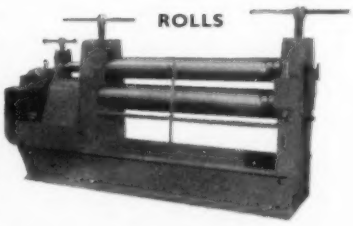

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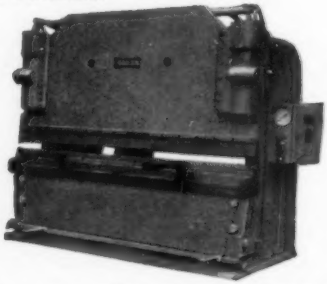

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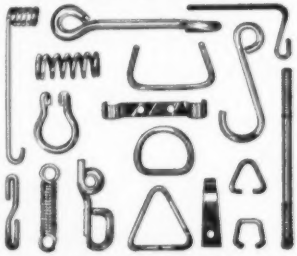

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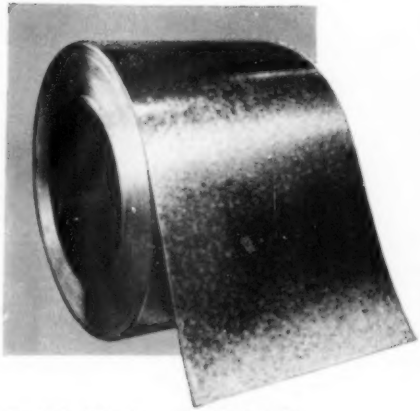

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